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OPERATION SNAPPER

Project 6.1

EVALUATION OF MILITARY RADIAC EQUIPMENT

REPORT TO THE TEST DIRECTOR

by

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January 1953

Classification (Cancelled) (Changed to UNCLASSIFIED
By Authority of Chief AFSWP 11/14/57
By R. Tawreby Date SEP 30 1958

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PREFACE

This report covers the operations of Project 6.1, Evaluation of Military Radiac Equipment, at the Nuclear Weapons Tests held at the Nevada Proving Grounds of the Atomic Energy Commission during the months of April, May and June, 1952. It is organized in three chapters, corresponding to the principal portions of the project, namely: (a) Radiac Survey and Dose-Alarm Equipment Evaluation, (b) Dosimeter Evaluation and (c) Rapid Aerial Survey.

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CHAPTER 1

RADIAC SURVEY AND DOSE-ALARM EQUIPMENT EVALUATION

1.1 ABSTRACT

Radiac equipment of current military interest was evaluated to determine its adequacy under representative field conditions. A limited amount of information was obtained on the maintenance and spare parts burden occasioned by field use of radiac equipment.

The following equipments are considered to have reached developmental maturity: AN/PDR-T1B, AN/PDR-18, AN/PDR-27 series and Tracerlab SU-13.

The following radiac equipments are considered to require further development work, and to exhibit sufficient promise in their present form to justify priority treatment in programming development work: IM-71/PD(XE-1), IM-70/PD(XE-1), NRDL #472 Recycling Ionization Chamber Dosimeter and Alarm, and AN/PDR-37.

Radiac equipments observed which are unsatisfactory in their current form but which may, nevertheless, be capable of development in a satisfactory form are: RD-102, AN/PDR-31, and AN/PDR-32(XN-2).

Modifications were developed which eliminate current operational and maintenance troubles with the AN/PDR-T1B and AN/PDR-27. Design and construction faults which became manifest in maintenance of the AN/PDR-18 are listed.

1.2 OBJECTIVE

The circumstances of a nuclear weapons test program offer a unique opportunity to obtain large scale usage of radiac instruments under conditions which approximate military operations. The objective of this portion of the project was to furnish radiac equipment of current military interest to users at the Nevada Proving Grounds, maintain service and maintenance facilities and records, note and investigate failures and inadequacies of the equipments, and try out such improvements as may be indicated by the investigations. The objectives were not fully realized since the principal users of radiacmeters (the Radiological Safety Organization) had established the policy of employing only the AN/PDR-T1B and the Beckman MX-5 meters for day-to-day operations. As a result, project personnel, as their dose tolerances permitted, were employed in survey exercises in available contamination fields to obtain as much operational use of

other military radiac equipment as possible under the circumstances.

1.3 BACKGROUND AND THEORETICAL DATA

The Radiac Evaluation Project is a project which has been included in the Military Effects Test for each of the recent nuclear weapons test programs.

A historical survey of military radiac development appeared in the report Operation JANGLE, Project 6.1, "Evaluation of Military Radiac Equipment." In addition to those radiac instruments whose development was traced in the referenced report, two Signal Corps Engineering Laboratories' experimental radiacmeters, the IM-70/PD(XE-1) and IM-71/PD(XE-1), and the NRDL #472 dosage alarm were evaluated.

The IM-71/PD(XE-1) radiacmeter is a miniature ionization chamber device employing a modification of the "floating electrode" chamber to drive an inverted vacuum tube electrometer voltmeter. Twenty-five (25) prototype models, constructed between January, 1952, and March, 1952, at the Signal Corps Engineering Laboratories, were available at the Nevada Proving Grounds.

The IM-70/PD(XE-1) radiacmeter is an ionization chamber device employing an orthodox chamber with an inverted vacuum tube electrometer voltmeter. Its high voltage power supply includes a transistor oscillator used as a d.c. converter. Twenty (20) prototypes were built during the same period as the IM-71/PD(XE-1) and brought to the Nevada Proving Grounds.

The NRDL #472 is a recycling dosimeter dose-alarm device employing an ionization chamber which is alternately discharged by radiation and recharged by a relay operation, the relay cycles being counted by a register which sums and indicates the total dose received. An adjustable alarm is provided which is set off by the register at any desired dosage. This instrument was evaluated in a very preliminary fashion at BUSTER-JANGLE and re-engineered prior to Operation TUMBLER-SNAPPER by USNRDL.

1.4 INSTRUMENTATION

1.4.1 Radiac Training Set AN/PDR-T1B

The radiac set AN/PDR-T1B is an ionization chamber type, gamma survey equipment. Information on the evaluation of the T1B is available in the 6.1 report for Operation JANGLE. The instruments tested during this operation were modified in accordance with the findings of that report. (See Fig. 1.1).

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Fig. 1.1 Radiac Training Set AN/PDR-T1B

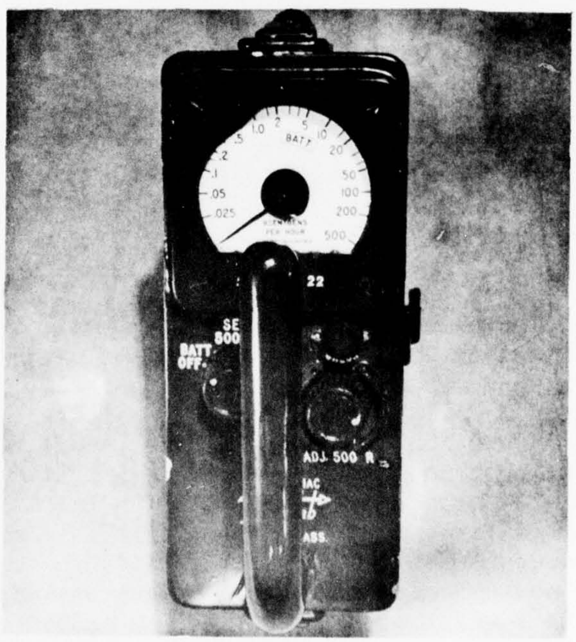

Fig. 1.2 Radiacmeter SU-13

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1.4.2 Tracerlab SU-13 Radiacmeter

The radiacmeter SU-13 is an ionization chamber gamma instrument. It has a logarithmic scale meter reading from 25 mr/hr to 500 r/hr. The dimensions of the unit are 7½" X 4½" X 3" and it weighs approximately 6 lbs. (See Fig. 1.2).

The circuit of the SU-13 employs three subminiature vacuum tubes, two of which constitute a linear feedback electrometer voltmeter measuring the voltage developed across the third tube which is operated as a logarithmic input element.

The battery complement consists of two 45-volt "B" batteries and four size "D" 1½ volt flashlight cells.

1.4.3 RD-102

The RD-102 is an ionization chamber type gamma survey instrument. It is a floating grid electrometer instrument having a two range logarithmic scale meter reading 1 mr/hr to 1 r/hr and 1 r/hr to 2000 r/hr. (See Fig. 1.3).

1.4.4 Radiacmeter IM-70/PD(XE-1)

The radiacmeter IM-70/PD(XE-1) is a small ionization chamber gamma survey instrument weighing approximately three pounds. It employs a standard ionization chamber and an inverted triode electrometer tube. It provides scale switching with five linear meter ranges of 0-0.05 r/hr, 0-0.5 r/hr, 0-5 r/hr, 0-50 r/hr, and 0-500 r/hr. One important feature of this instrument is the use for the first time of a transistor power supply, which supplies a 400-volt sweep-out voltage for the chamber. (See Fig. 1.4).

1.4.5 Radiacmeter IM-71/PD(XE-1)

The radiacmeter IM-71/PD(XE-1) is a small beta-indicating, gamma measuring ionization chamber type instrument employing an inverted triode electrometer tube circuit with a floating control electrode. It has a total weight of 1 lb. 2 oz. and uses two mercury batteries with a life of approximately 200 hours. It has a five decade pseudo-logarithmic meter scale reading from 0.02 r/hr to 500 r/hr. The instrument contains a thallium-204 source for calibrating in radiation fields. The calibration source is mounted on a rotating aluminum disc on the outside of the instrument case which, when rotated to the proper position, places the source over the ionization chamber window. Another position of the disc opens the window of the ionization chamber for beta indication. A carbon-14 source inside the chamber provides continuous ionization to increase the stability of the instrument. (See

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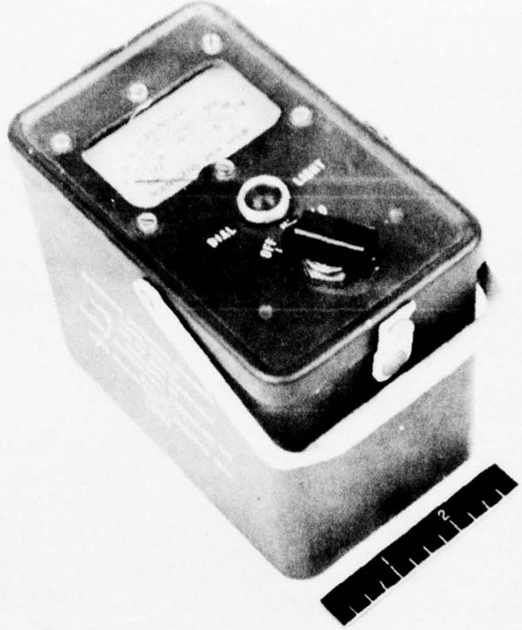

Fig. 1.3 Radiacmeter BD-102

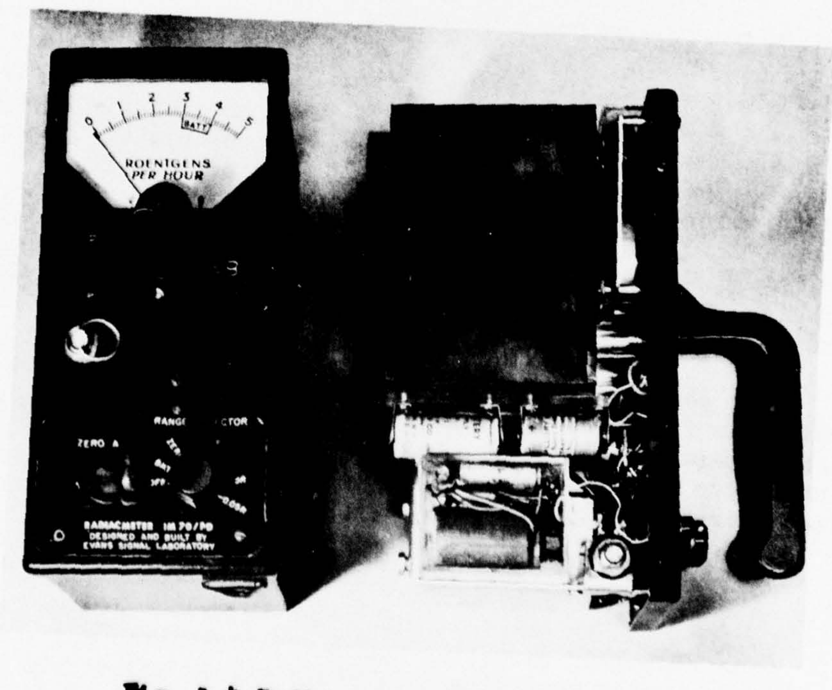

Fig. 1.4 Radiacmeter IM-70/PD(XE-1)

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Fig. 1.5).

1.4.6 Radiac Set AN/PDR-18

The radiacmeter AN/PDR-18 is a high intensity scintillation type gamma radiation survey meter. The detection of radiation is accomplished by means of a phosphor element. Impinging radiation causes the phosphor to fluoresce. This fluorescence is measured by a photomultiplier tube, the output of which is directly connected to the grid of a pentode comprising one arm of a balanced bridge. The degree of unbalance of the bridge is proportional to the radiation being measured. (See Fig. 1.6).

1.4.7 Radiac Sets AN/PDR-27 and AN/PDR-27C

The radiacmeter AN/PDR-27 is a Geiger-Mueller type instrument for measuring gamma or indicating beta radiation. It has four ranges: 0-0.5 mr/hr, 0-5 mr/hr, 0-50 mr/hr, 0-500 mr/hr. The two more sensitive ranges are obtained by using a thin, end window tube (BS-1) in a probe. The end of the probe is protected by a shield which is removed for indicating beta and gamma. The two higher ranges are provided by a second tube (BS-2) inside the case of the instrument. (See Fig. 1.7).

1.4.8 Radiac Set AN/PDR-32(XN-2)

The radiacmeter AN/PDR-32(XN-2) is a portable survey meter weighing 2 lbs. 2 oz. designed to measure gamma or indicate beta radiation. The sensitive element of the instrument consists of two miniature halogen-quenched Geiger-Mueller tubes. The average current, resulting from the pulses in the tubes, is converted to a pulsed current by means of a chopper, fed through an impedance matching step-down transformer, and rectified by a half-wave crystal rectifier in the meter circuit. A current gain of the order of 80 results from the inverter-transformer-rectifier operation.

The power supply of the AN/PDR-32(XN-2) utilizes two BA-30 flashlight cells in series to drive a 3-volt vibrator which has an output of approximately 750 volts. This output is rectified by a cold cathode half-wave rectifier and regulated by means of two adjustable corona regulator tubes, one for each Geiger-Meuller tube. (See Fig. 1.8).

1.4.9 NRDL #472

The NRDL #472 recycling ionization dosimeter and alarm is an electronic dosimeter providing an audible alarm, adjustable from 0-25 r. The sensitive element of the instrument is an ionization

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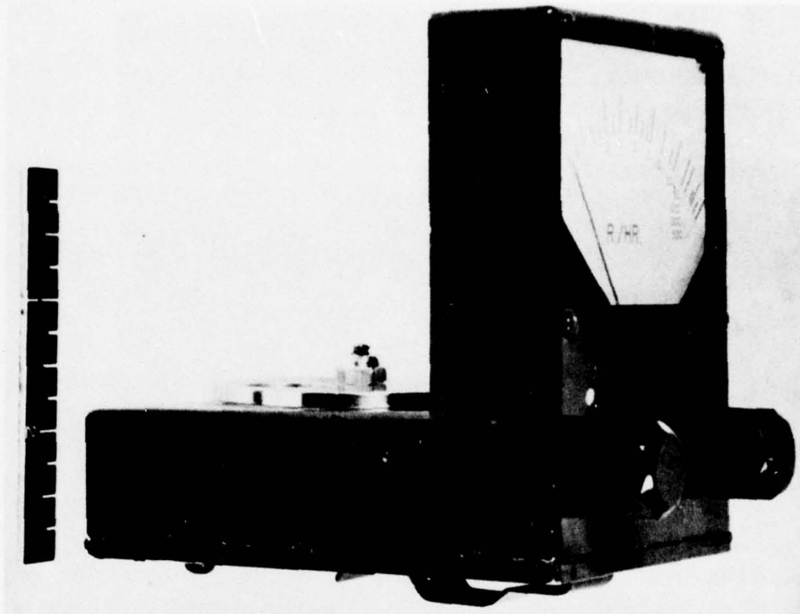

Fig. 1.5 Radiacmeter IM-71/PD(XE-1)

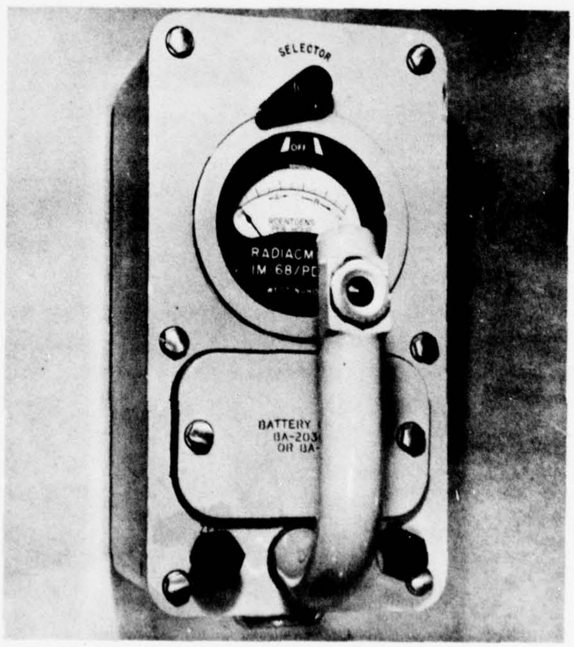

Fig. 1.6 Radiac Set AN/PDR-18

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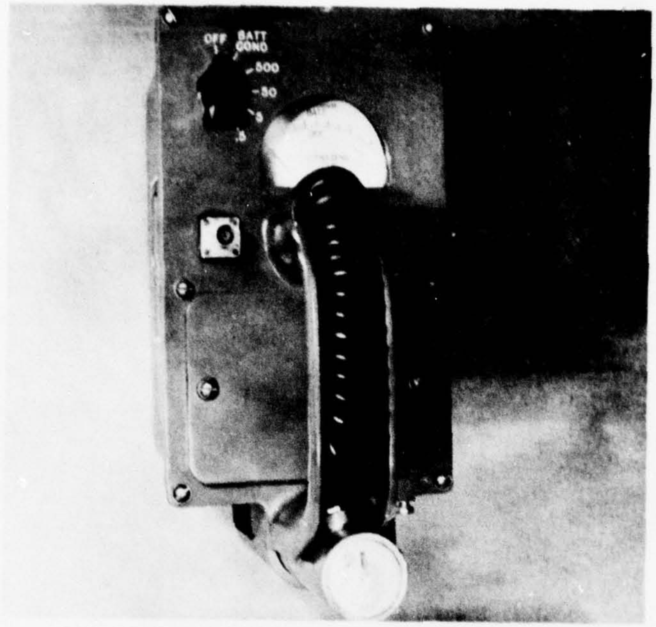

Fig. 1.7 Radiac Set AN/PDR-27

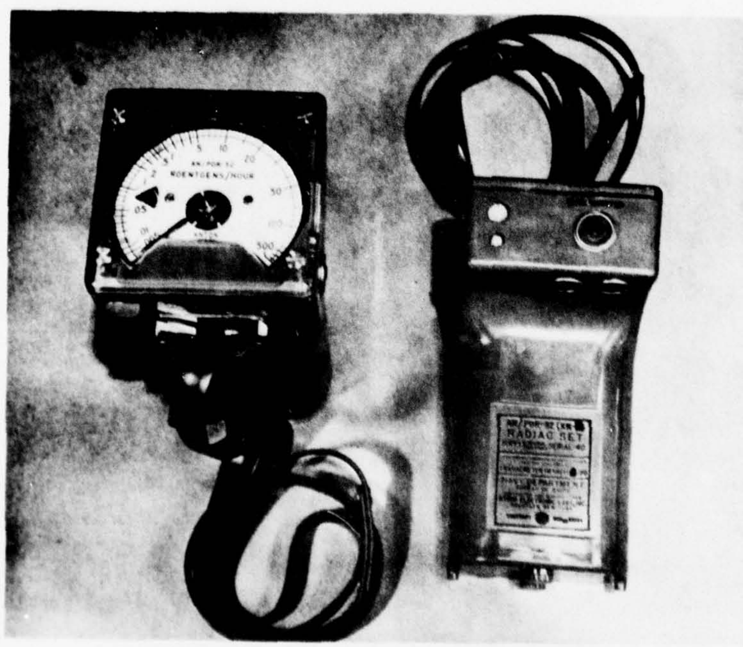

Fig. 1.8 Radiac Set AN/PDR-32(XN-2)

chamber with a collection voltage of approximately 90 volts. When the collection voltage is reduced to approximately 65 volts, as a result of ionization in the chamber, the cathode current of the electrometer tube, which is used inverted, is sufficient to operate a micro-relay. This relay in turn operates a power relay. The dose required to produce this drop in collection voltage is 5 mr.

When the power relay closes, two operations result: (1) an escapement is actuated through one cycle which allows a spring loaded drum register to advance; (2) a 90-volt battery is placed across the chamber to recharge it. When the chamber is recharged, the cathode current of the electrometer is reduced and the micro-relay opens.

Each cycle is made evident to the user by the advancement of the drum register and a neon flasher. Exposure may also be called to the attention of the user by making use of an alarm buzzer which can be set for any dose within the range of the instrument.

The drum register is divided into major steps of 1 r and subdivided into 200 mr divisions. One of the instruments tested was modified to have a total range of 4 r with scale subdivisions of 20 mr. (See Fig. 1.9).

1.4.10 <u>Radiac Set AN/PDR-31</u>

The AN/PDR-31 recycling ionization chamber dosimeter and alarm is similar in operation to the NRDL #472 described above. Three basic differences are: (1) the range, 0-200 r and 0-1000 r with a 3 r minimum alarm setting; (2) the use of a gas-tube relay in place of the micro-relay, and (3) the use of an orthodox electrometer circuit instead of the inverted triode electrometer. (See Fig. 1.10).

1.4.11 <u>Radiac Set AN/PDR-37</u>

The radiac equipment AN/PDR-37 is a portable, meterless, gamma survey instrument. It is a Geiger Mueller tube instrument operating on a three-volt vibrator power supply.

The principal of operation of the instrument is based on a thyratron fed back in such a way that the circuit oscillates at and above a given grid bias. The grid bias is determined by the radiation rate at the Geiger-Mueller tube and by the setting of a potentiometer voltage divider in the tube circuit. The potentiometer setting is used to determine the bias at which the circuit just begins to oscillate, being calibrated in r/hr. Earphones are used to determine the point of oscillation. (See Fig. 1.11).

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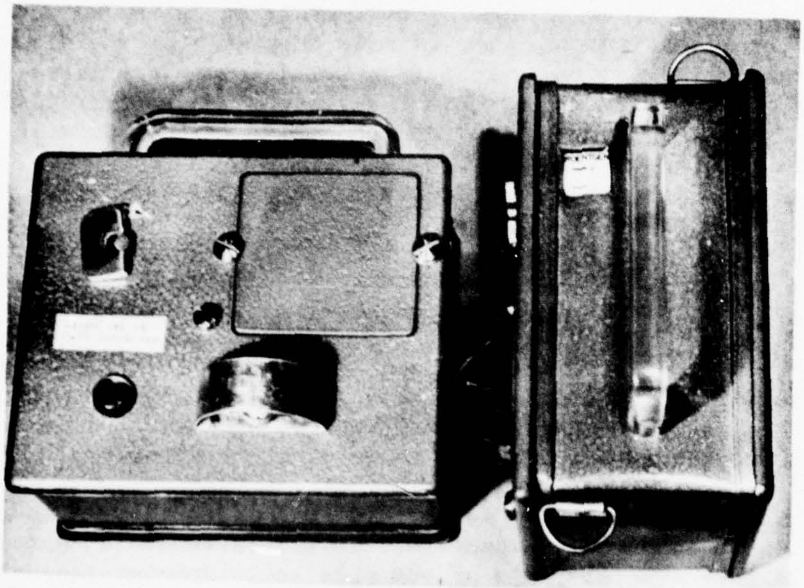

Fig. 1.9 NRDL #472 Recycling Ionization Chamber Dosimeter

Fig. 1.10 Radiac Set AN/PDR-31

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1.5 OPERATIONS

1.5.1 Discussion

Evaluation of radiacmeters by Project 6.1 involved two phases. (1) A radiac instrument shop and calibration facility was maintained at building #CP-2, in which maintenance and calibration service was provided for all radiac instruments employed in the operation. Records were maintained on maintenance operations and any unusually frequent failures were investigated for their causes. In addition to maintenance, this shop expended approximately six man-months in installing modifications in AN/PDR-T1B's owned by the Radiological Safety Organization. Shop experience resulted in investigation of T1B and PDR-27 troubles for which corrective measures were found. (2) The field phase of radiac evaluation was originally intended to include extensive use of project instruments by Radiological Safety personnel and by troops engaged in Nuclear Weapons maneuvers in addition to smaller scale radiac field drills by project personnel. The latter type of operation proved to be the only means available to obtain field hours on equipment and obtain opinions on their adequacy. This portion of the program was carried out by project personnel who were brought on the site because of their permanent interest in field operations, assisted by such casual visitors and observers as were available. Approximately 500 equipment use hours were obtained in moderate fields (up to 10 r/hr), the limiting factor being the maximum allowable dose for the personnel involved.

1.5.2 Recommendations

The sponsoring military agencies have indicated interest in evaluation of radiac equipment for operational adequacy in the hands of typical end users (as distinguished from technical adequacy). To accomplish this, it is recommended that all military organizations using radiac instruments at Nevada Proving Grounds (Radiological Safety, Camp Desert Rock, etc.) be given specific participation in a program for providing sufficient usage hours on service type equipments to satisfy project requirements. To facilitate record keeping, it is recommended that issue of all Nevada Proving Grounds' radiac equipment be made a Project 6.1 responsibility in charge of a military officer with enlisted assistance as required.

1.6 RADIAC TRAINING SET AN/PDR-T1B

1.6.1 Results

The radiacmeter AN/PDR-T1B, having been tested on Operations GREENHOUSE and JANGLE, was not evaluated on this operation in the same sense as the other instruments tested. It became involved in Project

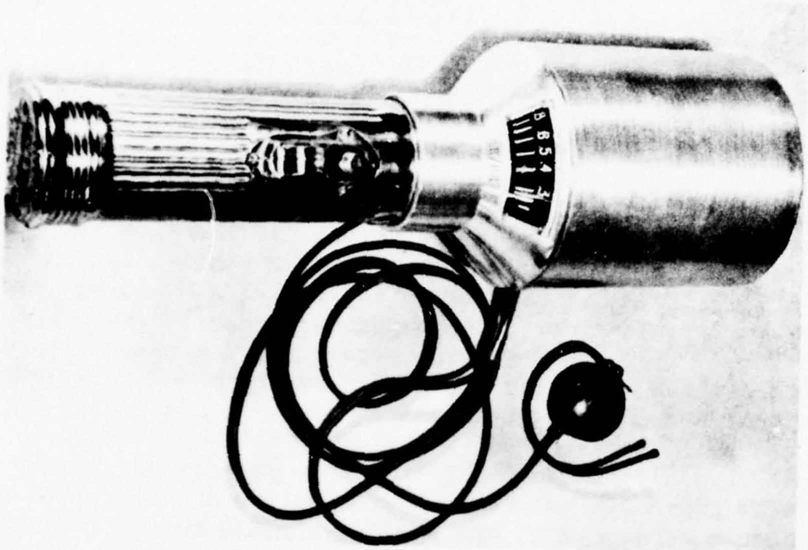

Fig. 1.11 Radiac Set AN/PDR-37

Fig. 1.12 First Switch Modification to AN/PDR-T1B

6.1 for two reasons: (1) as a result of information obtained at Operation JANGLE, two modifications were performed at the site on those AN/PDR-T1B's used by the Radiological Safety organization, (2) all instruments used by the Radiological Safety organization were maintained by the instrument repair shop of this project.

The instruments modified were used continually by the on-site and off-site monitors and not one failure resulting from either modification occurred. The maintenance records kept on the AN/PDR-T1B's indicate that the only outstanding maintenance problem on the modified instruments was failure of the meter movement. Six meters were replaced in the T1B's. The same meter movement was used in the IM-70/PD(XE-1) and the IM-71/PD(XE-1) and several meter failures resulted. In a few cases, iron filings were found in the meter movement.

1.6.2 Discussion

Two modifications were performed on the radiacmeter AN/PDR-T1B to reduce maintenance and to eliminate the switching transient characteristic of the instrument, especially on the sensitive ranges.

The first modification was to replace the "telephone type" leaf switch with a conventional rotary type switch. This modification arose from the fact that during Operation JANGLE, over 50 per cent of the maintenance performed on the T1B resulted from malfunctioning of the leaf switch. (See Fig. 1.12).

The second modification resulted from an investigation, during this operation, of the transient that occurs when the meter is switched from one range to another. It has been found that while some T1B's have little meter movement in switching from one scale to another, most of them have erratic deflections with various recovery times. In some cases the switching transient caused the meter to be unreadable for periods up to 25 seconds. The apparent cause of the transient was a signal on the grid of the electrometer tube produced by electrostatic induction between the bound charge distributions on the ceramic rotor and the radial guide prongs of the stator -- both parts of the range switch. The effect was such that the transient occurred even though the high-megohm circuit was wired to by-pass the switch, showing that the cause was not within the conductive circuit itself. By removing the guide prongs of the switch stator and fastening the rotor to the shaft for mechanical strength, the transient was reduced to an almost undetectable amount. In a few cases a minor residual effect remained and this was eliminated by conductive painting of the peripheral surface of the rotor ceramic to form a guard ring with respect to the stator charge distribution. (See Fig. 1.13).

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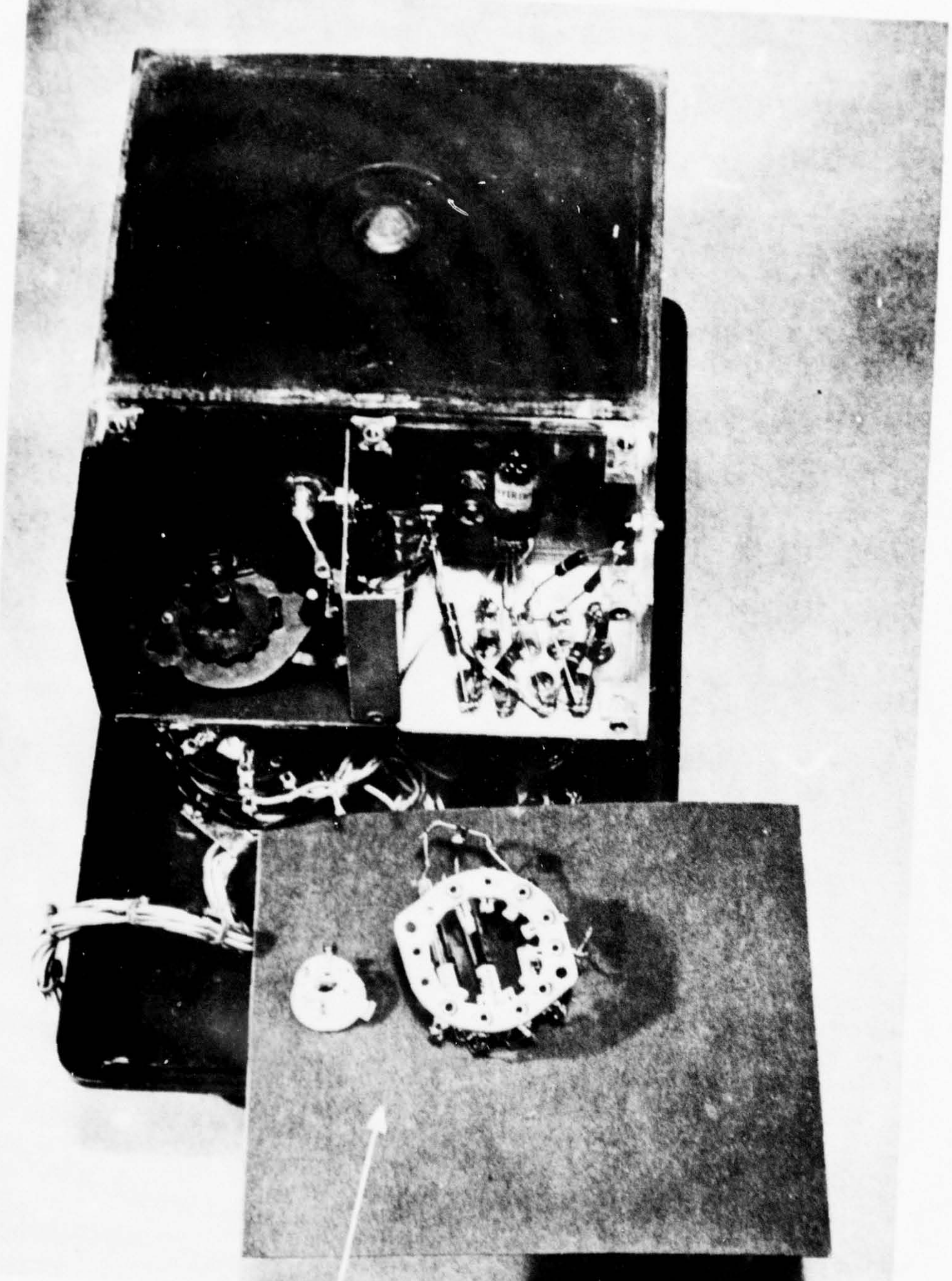

Fig. 1.13 Second Switch Modification to AN/PDR-T1B

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1.6.3 Conclusions

The radiacmeter AN/PDR-T1B, with two modifications previously discussed, constitutes, exclusive of form-factor, weight, and range limitation, a satisfactory interim survey instrument and warrants no further development due to the anticipated availability of newer lightweight, high-range instruments in the near future.

The excessive occurrence of faulty meter movements indicates that improvement in quality control is needed in this component if additional instruments are procured.

1.6.4 Recommendations

It is recommended that a modification work order, with the required modification kits, be initiated to modify those AN/PDR-T1B's now in the field and in service depots in accordance with the findings of this report. It is also recommended that this modification be included in any of these instruments produced in the future. Because of the significant number of failures of meter movements in this equipment it is recommended that better quality control be exercised on this component in future procurements.

1.7 TRACERLAB SU-13

1.7.1 Results

The radiacmeter SU-13 proved to be a relatively rugged, reliable, and generally satisfactory instrument with a few exceptions as noted below:

1. It is too heavy.
2. The luggage type fasteners on the case are not satisfactory.
3. The calibration procedure was not satisfactory.
4. The "adjust 500 r" knob was frequently disturbed accidentally.
5. The instrument should have a better "on-off" indication.

1.7.2 Discussion

Although the SU-13 is smaller and lighter than gamma survey instruments in present military use, development models of survey instruments now being tested indicate that even much smaller and lighter adequate survey meters can be made. Also, compared to newer types of instruments, the circuit of the SU-13 is unnecessarily complicated.

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The luggage type fastener used to hold the instrument in the case encourages tampering by unqualified personnel. In one case, the lug, cast as a part of the face of the instrument, broke during a normal closing operation.

The calibration procedure, though straightforward, is complicated by the fact that it is necessary to remove the instrument from the case and remove the batteries in order to adjust the decading of the instrument. However, once calibrated, the instrument retained its calibration well.

The "adjust 500 r" knob should be modified in such a way as to decrease the possibility of accidental movement. The "on-off" knob should be modified in a manner which would give a more positive indication of its setting. Numerous cases of operators failing to turn the instrument off resulted from the lack of such a positive indication.

1.7.3 <u>Conclusions</u>

Although the radiacmeter SU-13 was found to be a fairly satisfactory gamma survey meter, it is concluded, in light of the development types of radiacmeters tested, that it is not an instrument of military interest. It has been shown that a smaller, lighter, and considerably cheaper instrument will better meet military requirements.

1.7.4 <u>Recommendations</u>

It is recommended that no emphasis be placed on the SU-13 as a military instrument.

1.8 <u>RD-102</u>

1.8.1 <u>Results</u>

The radiacmeter RD-102 was found unsatisfactory as a gamma survey meter in the following respects:

1. Poor readability.
2. Poor reliability of readings.
3. No external "zero" adjustment.

1.8.2 <u>Discussion</u>

The most frequent comment by users of the RD-102 was that the meter scale was difficult to read. The scale is both small and printed in such a way as to not be conducive to easy reading. The close proximity of the high and low scales was confusing.

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It was found, during those field exercises in which the RD-102 was used, that the readings were not consistent. The readings of one given instrument were sometimes higher and sometimes lower than a group of instruments with which its readings were being compared.

The fluctuation in readings described above prompted comments from users that an external "zero" adjust is needed.

1.8.3 <u>Conclusions</u>

It was concluded that the RD-102 is not a satisfactory instrument for military use.

1.8.4 <u>Recommendations</u>

It is recommended that the RD-102 not be considered for military use. It is felt that it does not warrant any military development.

1.9 <u>RADIACMETER IM-70/PD(XE-1)</u>

1.9.1 <u>Results</u>

The limited testing to which the Radiacmeter IM-70/PD(XE-1) was subjected indicates the following results:

1. Size and weight satisfactory.
2. Range satisfactory.
3. Time-constant unsatisfactory.
4. The transistor power supply, though it shows promise, requires further development to increase stability.
5. General packaging unsatisfactory. However, it is realized that this instrument is a laboratory built model designed to test basic ideas and not engineering design.

1.9.2 <u>Discussion</u>

The size and weight of the IM-70/PD(XE-1) are small enough to be classed as satisfactory. However, it is felt that its size could be further reduced.

The strongest objection to the IM-70/PD(XE-1), in the form in which it was tested, was the long time-constant of the meter. In a number of cases the time-constant was so long, erroneous readings were obtained by the operator failing to wait until the meter had reached an equilibrium reading. During this operation a circuit change was developed which improved the time-constant to an extent that was con-

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sidered satisfactory. This circuit change was made on one instrument only, however, and was not subjected to sufficient tests to allow comment on its adequacy in other respects.

The transistor power supply, which operated on three small mercury batteries, did not give the stability obtained by operating the instrument on a battery supply. In addition, several of the transistor power supplies failed. However, sufficient operation on this power supply was obtained to indicate that the development of such a power supply may be possible.

1.9.3 Conclusions

The IM-70/PD(XE-1) is of sufficient interest to warrant further research and development in this approach to the problem of producing a small, light weight, survey meter. The transistor power supply shows sufficient promise to warrant further development.

1.9.4 Recommendations

It is recommended that development of an instrument to include the basic ideas incorporated in the Radiacmeter IM-70/PD(XE-1) be conducted on a priority basis.

1.10 RADIACMETER IM-71/PD(XE-1)

1.10.1 Results

The Radiacmeter IM-71/PD(XE-1) received varied usage during the operation including a parachute jump in Nuclear Weapons maneuvers by Desert Rock troops. The tests performed indicate the following:

1. Size and weight satisfactory.
2. Readability and reliability satisfactory.
3. Calibration procedure satisfactory.
4. Rotating aluminum disc for operating beta shutter and placing calibrating source in front of ionization chamber not satisfactory.
5. Calibration adjust knob too sensitive.
6. Charge on meter glass produced by rubbing caused instruments to become inoperative.
7. General packaging not satisfactory. However, it is realized that the instruments were laboratory built and were not intended for testing engineering design.
8. Many troubles resulted from the T13 meter movements used in these instruments.
9. Form factor satisfactory for belt operation. Numer-

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ous suggestions for other form factors were received.

1.10.2 Discussion

The size, weight, and simplicity of the Radiacmeter IM-71/PD(XE-1) represents a distinct improvement in the design of a survey meter for military use. The models tested leave much room for improvement, principally in the form of proper mechanical engineering. However, the instruments tested were generally satisfactory.

The readability of the instrument was good. The instrument was most reliable between 100 mr/hr and 100 r/hr. This is the range of greatest probable operational use.

The calibration of the instrument is a simple procedure. However, the caps for the holes in the case, through which a screwdriver is inserted for adjusting the internal calibration potentiometer, were easily lost.

The rotating disc which operates the beta shutter and places the source over the window of the ionization chamber was not considered good mechanical design. It also affects the energy dependence adversely. There was some question as to the practicability of using a source for calibrating the instrument. If a source is used it should be placed inside the instrument with a shutter device.

The reactions to the form factor were divided between those who favored belt operation and those who favored an instrument that could be carried in a jacket pocket. Many suggestions were received and passed on to the interested laboratory.

Comments with reference to packaging and components are not stressed because of the fact that the instruments were produced solely to test basic ideas.

1.10.3 Conclusions

It is concluded that the IM-71/PD(XE-1) is a realistic approach to the problem of developing a small, inexpensive, light-weight survey meter. It was found satisfactory for both beta indication and gamma measurement. The results obtained, from the varied usage to which the instrument was subjected, indicate that such an instrument shows great promise for military use. It is felt that future research and development efforts in the survey meter field should be channeled along the lines of this or similar instruments.

[redacted]

1.10.4 Recommendations

It is recommended, in view of the successful operation of the IM-71/PD(XE-1) that emphasis in the survey meter field be placed on that research and development required to put this instrument into production. The size, weight, and low estimated production cost of the IM-71/PD(XE-1) are such that it is recommended that work on this problem be given the highest priority.

1.11 RADIAC SET AN/PDR-18

1.11.1 Results

The radiac set AN/PDR-18 received approximately 150 service hours, all in the hands of project personnel. Results of evaluation are tabulated:

1. Size and weight are excessive as noted in the JANGLE Project 6.1 report.
2. Carrying means (handle and shoulder strap) are acceptable.
3. Range switching is unsatisfactory.
4. Calibration procedure is unsatisfactory.
5. Decade accuracy and scale linearity are satisfactory.
6. Case and chassis design is deficient in minor items.
7. Time-constant is satisfactory.
8. Condition and adjustment as received from the manufacturer are unsatisfactory.
9. Satisfactory performance at 15,000 feet altitude was obtained.

1.11.2 Discussion

AN/PDR-18 radiac instruments were employed in fields up to 400 r/hr, the maximum field being obtained during an airborne pass over ground zero. Only a few seconds of service at this highest intensity was observed. Performance in fission product fields of the order of 1 r/hr was satisfactory, parallel to that of air ionization chamber equipments.

The equipments on receipt were calibrated, inspected, and adjustments made as necessary. It was found necessary to clean and lubricate all "O" ring shaft seals, since a moderate amount of binding was evident. The range switching mechanism is coupled via an interrupted tooth gear train to the optical shutter which (1) exposes the photomultiplier to the standard light source in the "Cal" position and (2) exposes the photomultiplier to the light from the scintillant in the reading positions. The gear train and shutter required con-

[redacted]

siderable driving torque, and the indexing detent mounted on the range switch does not have sufficient locking torque to provide positive indexing. Calibration error may result.

Considerable trouble was found in adjusting the optical geometry of the standard light source. The difficulty stems from lack of rigidity in the source mounting, so that the adjusting screw cannot be locked up without disturbing the adjustment.

One unit was received with the rear sub-panel hanger bracket carried away from its welded anchorage on the battery case, apparently from a downward shock which caused no other damage.

Cover screws thread into aluminum bushings in the instrument case. The bushings are installed with screw driver slots facing the case bottom, so that they cannot be easily removed or tightened. Binding occurs in the cover screw-to-bushing fit, and repair is quite difficult.

Equipment serial numbers are so small as to be unreadable in many cases.

1.11.3 Conclusions

The AN/PDR-18 radiac set is considered to be, with the exception of size and weight, an adequate interim equipment for military use. It requires minor redesign of unsatisfactory mechanical details. No further development effort in the field of portable scintillation-photomultiplier equipments is indicated. Availability of a suitable high gain gas-multiplying phototube could, however, revive development interest in scintillation type equipment.

1.11.4 Recommendations

It is recommended that:

1. No further development be undertaken on the AN/PDR-18 except to remove present engineering deficiencies.
2. Silicone grease lubrication be applied to all shaft seals.
3. Range switch be modified so as to include a high torque detent.
4. Standard light source mounting and adjustment mechanism be redesigned to provide positive micrometer adjustment.
5. Shutter drive gearing be redesigned.
6. Mounting of sub-panel be strengthened.
7. Noted deficiencies in cover screw bushings be elimi-

[redacted]

nated. Anodizing or substitution of gray iron may be satisfactory.

1.12 RADIAC SETS AN/PDR-27 and AN/PDR-27C

1.12.1 Results

A total of 120 AN/PDR-27 series radiacmeters were made available to the project. Approximately 175 hours of use were obtained in the hands of project personnel. The equipments had not been modified in any way to remove the deficiencies noted in the Project 6.1 Report, Operation JANGLE. These deficiencies were so objectionable to the Radiological Safety Organization that it would not consider the equipment usable for its operations. As a result, an opportunity to observe large scale usage under typical field conditions was regrettably lost. Results of observation are tabulated:

1. Deficiencies noted in the Project 6.1 Report, Operation JANGLE, are reaffirmed.
2. No means of obtaining sufficient sensitivity range in the probe is available except by replacement of the BS-1 Geiger-Mueller tube.
3. The "canned" univibrator and voltage regulator units Z-101 and Z-201 are unsatisfactory.
4. Calibration provision is unsatisfactory.
5. The thin end window Geiger-Mueller tube is unsatisfactory as a probe, being both inconvenient and fragile.

1.12.2 Discussion

The greatest single item of dissatisfaction in the entire project was the inability to obtain large scale operational employment of the AN/PDR-27 as had been anticipated. The Project 6.1, Operation JANGLE Report recommended that such modifications as extending probe range, providing window protection, improving carrying strap, relocating probe cable, etc., be made. The failure to effect these improvements is responsible for the low acceptability of the AN/PDR-27 at the Nevada Proving Grounds.

A few crude attempts were made by the project to improve sample instruments. Two equipments were modified by reducing the trigger pair threshold voltage to 0.6 volts to extend the linear range of the BS-1 Geiger-Mueller tube. A 10 mr/hr range was desired, but only about 8 mr/hr was obtained with negligible non-linearity. Another equipment was modified by replacing the BS-1 Geiger-Mueller tube with an Anton #106 and also reducing the trigger threshold voltage as noted. A linear probe range was obtained to 20 mr/hr with a total (non-linear)

[redacted]

range of 50 mr/hr. A Beckman MX-5 probe was rebuilt for this equipment. Radiological Safety personnel interviewed indicated some approval of the modified instrument. It was quite apparent that the end-window tube, per se, is not convenient for personnel or vehicular beta monitoring. Use of a thin wall tube of the Eck-Krebs form may reduce monitoring time by a factor of two.

A persistent failure (10 were noted) of the AN/PDR-27 series was evidenced by the appearance of a meter reading on all scales in the absence of radiation. The cause, uniform in all cases noted, is the loss of insulation in the Z-101 or Z-201 "plug-in unit", the result of the deposit of a low resistance film from the potting wax on the surface of capacitor C-202, tube V-202 or the phenolic base of the unit itself, thus applying B plus to the V-202 grid. V-202 is maintained in conduction by the reduction of grid bias, and its steady plate current is metered. Clean-up with a brush and solvent, or simply by scraping, restores the unit to service.

Calibration of the 27 series is very time consuming, since each of four decades must be calibrated independently and the chassis replaced in the case for exposure to the source. A jig or dummy case has been designed to permit access to the calibrating potentiometers but this equipment was not made available to the project.

1.12.3 Conclusions

It is concluded that:

1. The AN/PDR-27 and 27C would be adequate interim radiac equipments for military use provided the modifications suggested in the report of Project 6.1, JANGLE were made.
2. The beta probe is unsatisfactory on grounds of convenience in use and sensitivity range.
3. Potting compound in Z-101 and Z-102 units is electrically unstable and a prime cause of unnecessary maintenance.
4. Calibration provisions are inconvenient.

1.12.4 Recommendations

It is recommended that:

1. The beta probe be redesigned and field modification initiated promptly. A Geiger-Mueller tube of smaller volume and/or shorter dead time is required. The product of volume and dead time should be of the order of 1/8 to 1/10 that of the BS-1 to provide

linear response at 50 mr/hr. A side window or thin wall form is recommended. If an end window tube is retained, window protection must be provided.

2. The potting compound used in Z-101 and Z-201 units be eliminated or replaced by a stable wax.
3. A design study be made to improve calibration provisions. For example, calibration potentiometers could be replaced by fixed resistors and calibration accomplished by adding two variable capacitors (one for each decade pair) connecting the grid of V-102 or V-202 to ground via the range switch. External calibration controls protected by water tight caps are recommended.

1.13 RADIAC SET AN/PDR-32(XN-2)

1.13.1 Results

A total of nine AN/PDR-32(XN-2) radiac instruments were made available to the project at about midpoint of the operation. A negligible amount of operational use was obtained, both because of the short period on site and because troubles developed immediately in the process of putting the equipments into service. None of the equipments were successfully calibrated or could be kept operative for a sufficient time to permit operational use and evaluation. The operational discrepancies observed during calibrating range operations follow:

1. At constant intensity, the meter indication varied by as much as 50 per cent for different geometric orientations of the radiac.
2. Random variations of meter indication occurred with the radiacmeter resting untouched on the range.
3. Light tapping with a pencil produced sudden changes of meter reading of as much as 2.5 to 1.
4. Some voltage regulators had insufficient range to permit calibration; that is maximum setting on the regulater did not bring the meter to full indication of the radiation field intensity..
5. Some vibrators were in marginal operating condition as received and failed to start after a few starting cycles. Bench adjustment was successful in every case in obtaining dependable starting.
6. Tracking of the radiacmeter indication with the calibrating gamma field was poor in those cases in which calibration at 100 r/hr and 0.1 r/hr was obtainable. Maximum tracking error appeared at about 5 r/hr field.

[redacted]

7. Calibration, when obtained, was not in general, stable from day to day.
8. Meter readability was unsatisfactory. It was necessary for the calibrator to accept considerable dose on the range in the calibrating process, in order to assure himself that readings were correctly obtained.
9. Two instances of case breakage occurred from falls of a few feet.

1.13.2 Discussion

As a result of the immediate operational troubles encountered with the AN/PDR-32(XN-2), it was considered necessary to investigate their causes and, if possible, to put the equipment into operational order.

Three vibrators, which had become inoperative were adjusted on the bench, observing the waveforms with an oscilloscope. The element adjusted was the arrest or detent which restrains the motion of the "fixed" contacts. The intent was to eliminate contact "bounce" if possible and to obtain a large reed amplitude. Dependable running and reasonably good waveforms were easily obtained.

Investigation of the positional vagaries of the radiac disclosed that the vibrator is decidedly geotropic, its frequency varying as it is rotated about a line parallel to the reed. No effect on the regulated high voltage supply results from the frequency shift, although the current input to the vibrator varies as much as 30 per cent. Chopper contact frequency is identical with reed frequency and the variation here produces serious results. Investigation of eight units disclosed an average variation of plus or minus 14 per cent in meter current with position. The resulting variation in meter indication (r/hr) may be as high as 70 per cent.

The Geiger-Mueller tube response is independent of position, so long as it is not in circuit with the chopper. However, in its normal circuit, the positional variation of chopper contact frequency results in variation in the time-averaged Geiger-Mueller tube current. This results from the fact that there are voltage pulses on the Geiger-Mueller tubes at the chopper frequency. These are 10 volts high in a 10 r/hr field. A change in the chopper duty cycle is thus reflected through the tube duty cycle on the time integrated Geiger-Mueller tube current. It may be noted that the contact closure period is hardly affected--the effect being due to variation in repetition rate alone.

It was found that some of the equipments as received, would respond to light tapping on the case with a large shift in vibra-

[redacted]

tor frequency, accompanied by a change of 2 to 1 or more in meter indication. Oscillographic examination disclosed a family of extra contact pulses associated with the frequency shift. It is presumed that the cause lies in the excitation of stable higher modes of oscillation in the reed, although the lack of stroboscopic equipment made the diagnosis uncertain. This effect was cleaned up by adjustment of the contact arrest in two equipments.

Lacking time, no investigation could be made of the stability of Geiger-Mueller tubes and corona regulators with reference to long term drift in characteristics. These are suspect, since (a) the meter scaling function (meter indication as a function of meter current) is not at present identical to the inverted sensitivity function (the radiation field as a function of total Geiger-Mueller tube currents), and (b) the corona regulators do not in all cases have sufficient range to calibrate the Geiger-Mueller tubes. It must be presumed that these two discrepancies were not present when the manufacturer shipped the equipments; thus the conclusion is inescapable that drifts have occurred.

Minor difficulties were experienced with operating controls--erratic operations of the on-off switch, binding of the beta shutter operating mechanism, and meter light switches that can be turned on by the weight of the radiac. The voltage regulator tube adjusting screw and housing are not securely clamped, and during adjustment may move the tube enough to short the high voltage terminal. Shorts also occurred on the high voltage supply due to failure of poor insulation on hook-up wire used.

1.13.3 Conclusions

The broad conclusion is inescapable that the AN/PDR-32 is enmeshed in too many unsolved components problems to permit sensible operational evaluation of the equipment as a whole. Conclusions indicated by project experience are:

1. The case form factor design is superior to any radiacmeter observed.
2. The case material is not sufficiently rugged for military use.
3. The vibrator-chopper unit is not sufficiently stable to perform its assigned function reliably.
4. Operating mechanisms (controls) are unnecessarily elegant and expensive.
5. Geiger-Mueller tubes and voltage regulating tubes are possibly unstable in characteristics with respect to age.
6. Meter readability is poor.

[redacted]

7. Voltage regulating tubes have insufficient range.
8. Development status is an illogical mixture of highly developed finished package engineering with unproven components and circuit engineering.
9. In summary, the AN/PDR-32 is not a technically adequate radiac instrument for military use in its present status.

1.13.4 Recommendations

It is recommended that:

1. The basic design philosophy of the output current amplifying system and of the high voltage regulating system used, be reexamined competitively with other potential designs.
2. Extensive stability studies be made of (a) halogen-quenched Geiger-Mueller tubes employed and (b) the adjustable voltage regulators.
3. A design study be made, aimed at a high stability vibrator drive.
4. Metal or laminated plastic case construction be considered.
5. Operating controls be redesigned and simplified.
6. Meter scale be redesigned for easier reading.
7. Solution of components problems and examination of design philosophy be given first priority.

1.14 NRDL #472 RECYCLING IONIZATION CHAMBER DOSIMETER AND ALARM

1.14.1 Results

The #472 Dosimeter saw only limited use at the Nevada Proving Grounds by project and senior Radiological Safety personnel as an adjunct to high-dose quartz fiber dosimeters on early survey and other high intensity field operations. Comment of using personnel indicates that a radiac instrument of this type may have a field application in the basic mission of supplying tactical information to troop units in nuclear weapons operations. A desire was evidenced to develop the unit in a package which could be carried in a pocket or as an item of belt equipment. It may be desirable to incorporate this type of dose information with a high range dose-rate information--perhaps 5-10 r/hr minimum indication. The instrument as delivered to the project had too coarse resolution for Nevada Proving Grounds use, where the operational tolerance is set at 3 r. One unit was project modified to indicate 4 r total dose with 20 mr scale graduations and this unit was well received.

[redacted]

Units were calibrated after receipt and found to be quite stable and reliable. Calibration and alarm set controls were inconvenient to use. Projecting switch toggles and rewind knobs were objectionable since they were easily snagged on clothing, vehicles, etc. — accidental turning off or disturbance of dose indication resulting. No service failures occurred resulting from circuit malfunction or component failures. Air operations and rough country operations in vehicles resulted in no malfunction or damage.

1.14.2 Discussion

The #472 is a development radiac instrument, rather crudely engineered and packaged, primarily to illustrate at Nevada Proving Grounds a type of radiac which has had little developmental attention. Better foresight in design would probably have resulted in much more extensive use during operation. Poor form factor resulted from overemphasis on minimizing the cycle increment of dose (5 mr was used), which required a large ionization chamber of low capacity. A suitable micro-relay could not be obtained and pilot relaying was employed, making further demands on cubage.

Maximum dose indication was chosen at 25 r, a figure having some standing as a possible military tolerance. Resulting dose resolution was not satisfactory for Nevada Proving Grounds operation where only about 10 per cent of the whole scale length was of any utility.

Calibration was performed on a collimated Co^{60} range by timing a few cycles at a known dose rate, and adjusting the spring tension on the micro-relay as required to bring the increment to 5 mr. The operation is tedious, requiring the use of earphones to count the cycles and a very critical adjustment to be made internal to the case.

1.14.3 Conclusions

It was concluded that:

1. The cycling ionization chamber dosimeter is a type of instrument that may have some troop operational utility.
2. The combination of this instrument with high level dose-rate indication should be further studied.
3. The current model is excessively bulky and heavy

1.14.4 Recommendations

It is recommended that:

1. Development of the #472 type of radiac be assigned priority.
2. Means of combining with high level dose-rate indication be investigated. It is possible that relay operations can be rate-counted by means of simple rate-meter circuitry.
3. Scale changing facility be included in design so that the same instrument is usable both for nuclear weapons test and maneuvers, and for war operations.
4. Use of igniter gas tube and hard tube trigger circuit relaying be investigated.

1.15 MISCELLANEOUS

1.15.1 Radiac Set AN/PDR-31

The radiac equipment AN/PDR-31 was not extensively tested for two reasons: (a) only two instruments were available, (b) the dose range and resolution are completely unsuited for weapons test use at the Nevada Proving Grounds.

1.15.2 Radiac Set AN/PDR-37

One unit was available. This radiac instrument is intended only as a model to illustrate the feasibility of a meterless radiac equipment design. Operation was in general satisfactory. The following recommendations are made:

1. The feasibility of a miniaturized radiacmeter of 4 or 5 decades range, employing potentiometer read out with message register type drum dials indication, be investigated.
2. Design studies be made of potentiometer read out systems, varying types of threshold signal and dial indications to determine if reduction in size, weight or power are available over D'Arsonval meter read out.

1.15.3 Air Sampler Jig for Radiac Set AN/PDR-27

A plastic reading jig for application to the AN/PDR-27 probe for determining activity of air filter samples was developed at USNRDL and submitted to Project 6.1. It is adapted to filter holders of the Chemical Corps Portable Air Sampler and of the NRDL - General Electric "vacuum cleaner" type. Interpolation of sample activity between known activities of Sr^{90} is made. No operational use was obtained--samples collected at Shots 7 and 8 being below minimum sensitivity of the device, although countable with good significance on a beta counter of 40 per cent geometry.

Recommendations are:

1. Jig be redesigned to increase geometry.
2. A jig for use with a thin wall Geiger-Mueller probe be designed, since this type of probe is decidedly superior for general purpose personnel and vehicle monitoring work.

1.16 RADIAC INSTRUMENTS - GENERAL

1.16.1 Conclusions

At the present time, there are no radiac instruments available to the military services which can be considered entirely satisfactory for their use. There are, however, instruments currently in production which, with relatively minor modifications, are adequate interim instruments. These are the AN/PDR-T1B, the AN/PDR-27 series, and the AN/PDR-18. Although these instruments are inadequate as standard items due to size, weight, range, complexity of circuit, production cost, or other reasons, they are, on a limited basis at least, available to the armed forces; and they will measure radiation.

In recent months considerable work has been done on miniaturization and simplification of radiac instruments. Results indicate clearly that small, relatively inexpensive instruments can be produced which will meet military requirements.

1.16.2 Recommendations

It is recommended that the modifications outlined in this report be made on the AN/PDR-T1B, AN/PDR-27 series, and the AN/PDR-18 in order to provide the military services with adequate interim instruments. It is felt, however, that no major development work should be done on any of these instruments and they do not warrant the expenditure of any funds other than those necessary for making them truly adequate interim instruments.

It is further recommended that emphasis be placed on the development and production of simple, light-weight, inexpensive survey instruments. All instruments presently being developed by or for the military services should be reconsidered competitively, with the intention of determining how military requirements can be met in the shortest time with a minimum of effort and expense.

CHAPTER 2

EVALUATION OF DOSIMETERS AND ASSOCIATED EQUIPMENT

2.1 ABSTRACT

Nine dosimeters, or associated components, of current military interest were tested at the Nevada Proving Grounds during operation TUMBLER-SNAPPER. Results indicate that none of the dosimeters tested are entirely satisfactory for military use. The DT-65/PD with its associated holders, PH-650/PD and PH-656/PD, is, however, satisfactory for interim use.

The charger PP-354C/PD was subjected to limited tests. For the conditions that existed at the test site, it operated satisfactorily.

2.2 OBJECTIVE

The dosimeter phase of Project 6.1 was conducted in order to subject those dosimeters of present military interest to the high dose rates and the energy spectrum characteristic of an atomic explosion. It was desired to determine the accuracy of dose indication, as compared to a standard, and the consistency of the indication among dosimeters of the same type. Both development and production type dosimeters were tested.

2.3 BACKGROUND AND THEORETICAL DATA

The dosimeter evaluation program is a continuation of the tests begun at Operation GREENHOUSE and continued at Operation BUSTER-JANGLE. The development types of dosimeters tested are those presently being examined as part of the Army Signal Corps dosimeter program, with the exception of the Taplin dosimeter, which is being developed under the auspices of the Army Chemical Corps.

2.4 INSTRUMENTATION

2.4.1 DT-65/PD Photographic Dosimeter

The DT-65/PD Photographic Dosimeter is a "dry" developing device using the Polaroid-Land process. The dosimeters used on this operation provided dose readings from 25 r to 675 r in 12 non-uniform steps. Readings are obtained by comparing the darkening, due to radiation, of a photographic emulsion, with a step wedge. This dosimeter is presently under production.

2.4.2 DT-64/PD Photographic Dosimeter

The DT-64/PD Photographic Dosimeter is identical in operation with the DT-65/PD. The range, however, is 1 r to 60 r. This dosimeter is still under development and not considered ready for production.

2.4.3 PH-650/PD Dosimeter Holder

The dosimeter holder PH-650/PD is a plastic holder for use with the Polaroid type photographic dosimeters. It is the non-developing counterpart of the PH-656/PD metal dosimeter holder in that it does not contain means for squeezing the chemical pod and spreading the developing chemicals. It is designed to carry three dosimeter plaques. The top portion of the holder is reinforced with metal to prevent the chemical pod from being crushed while the dosimeter is worn.

2.4.4 Taplin Dosimeter

The Taplin dosimeter is a step type, color-change dosimeter consisting of four glass vials containing a two-phase, chloroform and water-alcohol system giving dosage steps of 50, 200, 400 and 600 r. The color indication is produced by a PH indicating, aqueous dye. The dosimeter also contains two control vials reproducing the colors before and after the change resulting from gamma radiation. The color change is based on an end point reaction and thus reading the dosimeter requires only recognizing the change of color and not interpretation of shades of the same color. On the inside of the aluminum case, which houses the six glass vials described, the dosimeter has a control "spot" which changes from pink to white if the vials have been subjected to sufficient light to cause erroneous readings as a result of the chloroform having broken down. The dosimeter is, however, relatively insensitive to both heat and light in its present package.

2.4.5 DT-51/PD Color Changing Crystal Dosimeter

The DT-51/PD color changing crystal dosimeter is a development form of a potassium bromide, F-center coloration system. It is designed to have a range of approximately 0-600 r. The color range resulting from radiation is determined in two ways. The color of the crystal is compared with standards in a small portable comparator. The color change of the crystal may also be determined by a photo-electric reader which measures the attenuation of a light beam in passage through the crystals.

2.4.6 DT-67/PD Conduction Crystal Dosimeter

The DT-67/PD conduction crystal dosimeter is also potas-

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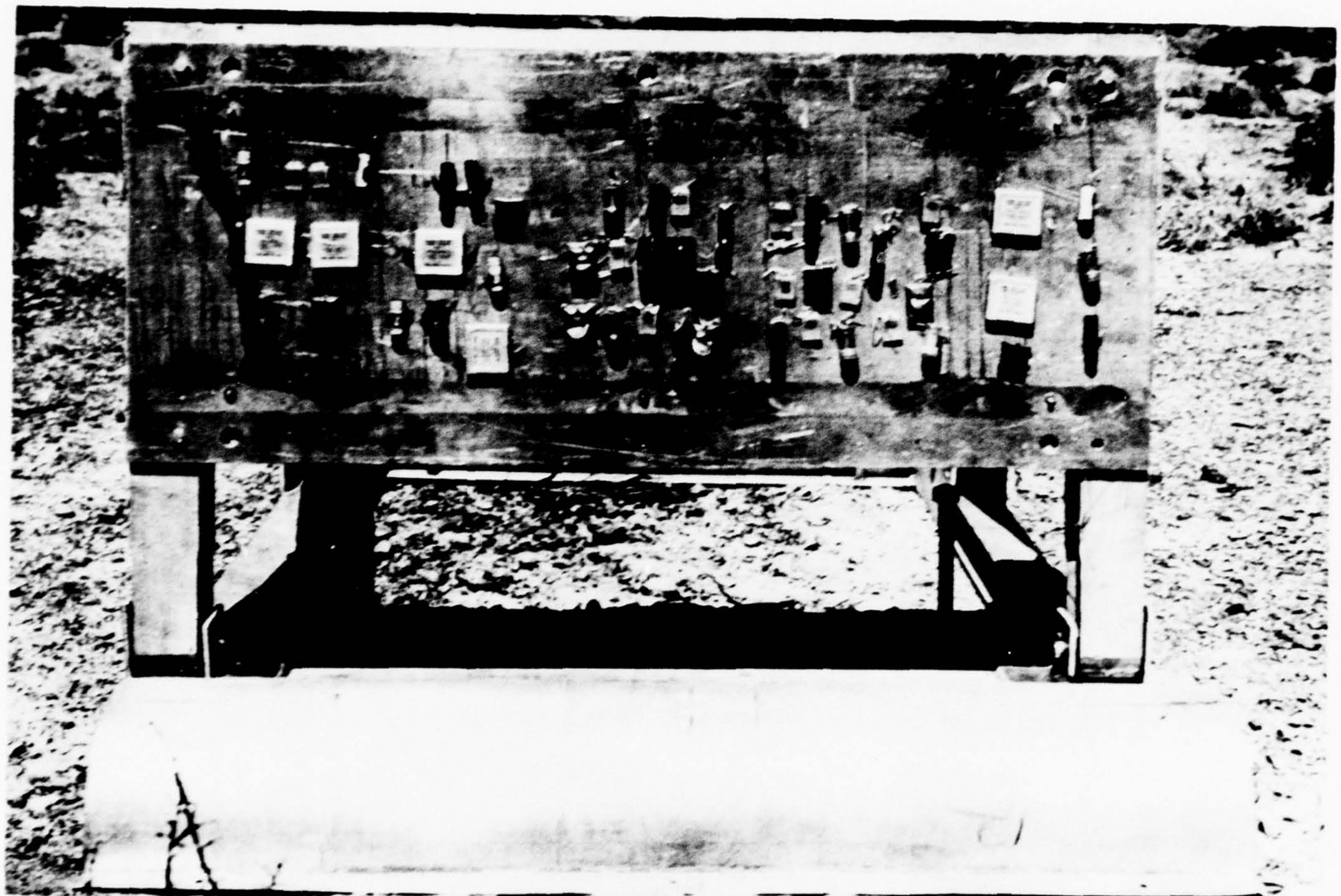

Fig. 2.1 Dosimeter Stations

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sium bromide. It is made up of small crystals in a glass vial. Subjecting the crystals to radiation results in electron trapping. After exposure, the trapped electrons are excited into the conduction band by an infrared source and the photoconductive change is measured. The reading is then proportional to the radiation dose. The range of the dosimeter is approximately 0-350 r.

2.4.7 Patterson-Moos "Atometer"

The Patterson-Moos "Atometer" is a color changing chloroform solution. When subjected to radiation, hydrochloric acid is formed and the color of the solution changes from yellow to red-yellow. The color of the solution is compared with standards provided on the package of the dosimeter to provide steps of 50, 150, 400 and 600 r.

2.4.8 Patterson-Moos Phosphor Dosimeter

Another type of dosimeter tested was a development model of a Patterson-Moos infrared photo-fluorescent phosphor. Gamma radiation causes electron trapping. When excided with infrared, the dosimeter fluoresces. The yield of fluorescent radiation is measured by a photoelectric reader and the reading calibrated in terms of gamma dose.

2.4.9 Dosimeter Charger PP-354C/PD

A portable batteryless dosimeter charger, the PP-354C/PD, was given very limited tests. It is a miniature, pocket device, approximately 1" x 2" x 2½", using a hand operated, friction electrostatic generator to charge fiber-electrometer, self-indicating dosimeters. The dosimeter being charged is read in the charging position by holding it up to the eye and allowing light to pass through the charger and dosimeter from the bottom.

2.4.10 Exposure Standards

In order to determine the amount of radiation to which the dosimeters were exposed, it was necessary to choose a standard to be placed at each exposure station. The standard chosen was the conventional film badge in the National Bureau of Standards holder. For more information see the report of Project 2.1, Operation TUMBLER-SNAPPER.

2.5 OPERATION

The dosimeters to be tested were attached to stations as shown in Figure 2.1. A 1/16" aluminum shield was used to protect the dosimeters from thermal and blast effects. The dosimeter stations were positioned along a line from ground zero at distances determined from predicted

dose-distance curves to give desired doses. Fourteen stations were used to obtain a sufficient range of doses between 1 r and 1000 r, predicted. To determine the doses to which the dosimeters were subjected, dental X-ray film packets in NBS holders were placed within the aluminum shields with the dosimeters.

The dosimeters and standards were positioned in the stations on the day before a shot and were recovered on shot day as soon as possible after detonation. This was done for shots three through eight of the TUMBLER-SNAPPER series.

The dosimeters were read as soon as was practical after each shot. In order to minimize human error, each self-indicating dosimeter was read by 5 to 10 people. The data thus obtained was organized in such a way as to show the accuracy of the dosimeter compared to the standard and the consistency within dosimeters of the same type.

2.6 DT-65/PD PHOTOGRAPHIC DOSIMETER

2.6.1 Results

Approximately 94 per cent of the DT-65/PD's exposed (about 2000) gave dose readings within plus or minus 25 per cent of their own mean reading at a given exposure. Also those dosimeters which received approximately 250 r or less agreed within plus or minus 25 per cent of the value recorded by the National Bureau of Standards badge for the same exposure. However, those dosimeters which received more than 350 r gave doses less than those recorded by the National Bureau of Standards badges. The error increased with the dose, giving an error of 50 per cent at 600 r. This is shown graphically in Figure 2.2. Table 2.1 shows the data from Shot 3 in the form in which the data was tabulated.

The reading of the DT-65/PD's was made somewhat difficult by the fact that the sensitive strips in the dosimeter did not give true shades of black or gray, but contained a pink tinge. Determining the dose reading required matching shades of two slightly different colors, and not shades of the same color. Less than ½ of 1 per cent of the DT-65/PD's tested had failures of the chemical pods.

2.6.2 Discussion

When it was learned that the DT-65/PD's were giving low readings at the high doses, the manufacturer's calibration was checked by exposing groups of the dosimeters to various doses from a Cobalt 60 source. The dosimeters thus exposed agreed with the manufacturer's calibration without a single discrepancy. This, coupled with the fact that those dosimeters which received the high doses were exposed to

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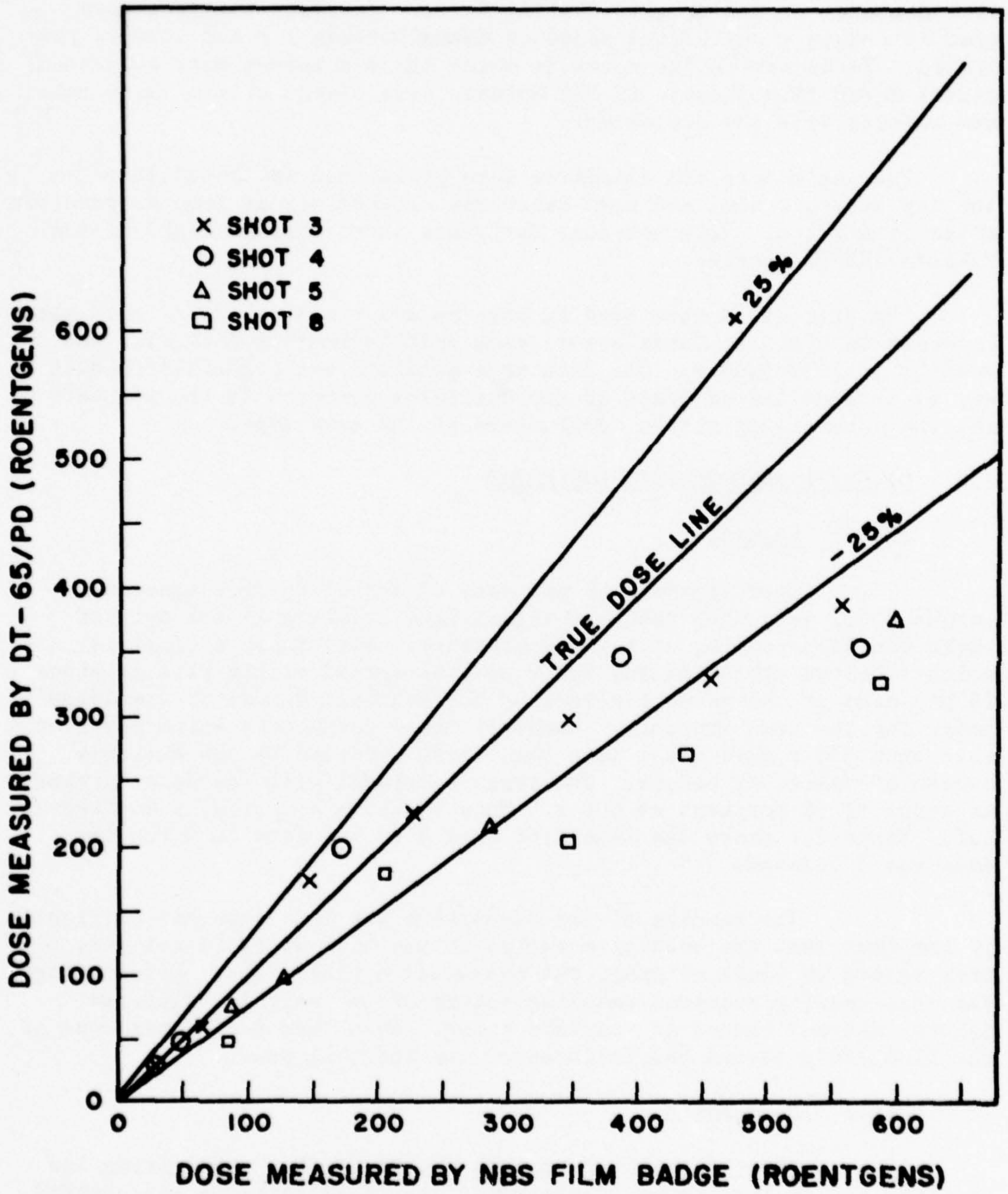

Fig. 2.2 Results, DT-65/PD

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TABLE 2.1

Results DT-65/PD

Sta. No.	Dose		Readings		Average Dose Read	Dose NBS Badge	Per Cent Diff.
	Step	r	Number	Per Cent			
1	I-J	343	1	0.5			
	J	395	140	69.5			
	J-K	445	33	16.4	414	832	
	K	495	27	13.4			
2	I	290	3	1.5			48.0
	J	395	191	9.7	395	560	29.5
	J-K	445	3	1.5			20.6
3	I	290	85	44.3			37.0
	I-J	343	43	22.4	334	460	25.4
	J	395	64	33.3			14.1
4	I	290	99	84.6			22.4
	I-J	343	13	11.2	300	374	9.1
	J	395	5	4.2			5.6
5	G-H	150	4	2.2			35.3
	H	195	97	53.7	222	232	15.8
	H-I	243	30	16.6			4.7
	I	290	46	25.6			18.1
	I-J	343	2	1.1			47.9
	J	395	1	0.6			70.4
6	G	105	3	1.4			42.4
	G-H	150	2	1.0	208	182	17.6
	H	195	174	83.5			7.2
	H-I	243	2	1.0			21.4
	I	290	27	13.0			59.3
7	G	105	72	31.8			21.6
	G-H	150	30	13.3	166	143	11.9
	I	195	120	53.2			45.5
	H-I	243	1	0.4			74.0
	I	290	3	1.3			116.0
8	C	50	2	1.35			30.2
	C-D	55	2	1.35	60	73	24.7
	D	60	140	94.6			17.8
	D-E	65	2	1.35			10.9
	E	70	2	1.35			4.0
9	A	25	16	10.2			16.6
	A-13	30	41	26.2	33	30	0.0
	13	35	102	64.0			16.6

higher dose-rates, indicates that this dosimeter may be subject to rate dependence.

The results of this test have been passed on to the interested

[redacted]

agency for investigation.

2.6.3 Conclusions

The DT-65/PD is an adequate interim dosimeter. The consistency of the dosimeter, its accuracy up to doses of 350 r and its simplicity make it worthwhile for use as a military dosimeter at the present time. However, it cannot in its present form be considered as the final answer to the dosimeter problem.

2.6.4 Recommendations

It is recommended that the investigation of the failure of the DT-65/PD at the high doses be given high priority. It is also recommended that when the problem is solved, this dosimeter be considered competitively with other dosimeters, taking into consideration production status, cost, simplicity, etc.

2.7 DT-64/PD PHOTOGRAPHIC DOSIMETER

2.7.1 Results

The results of the exposure of the DT-64/PD are given in graphical form in Figure 2.3. Approximately 53 per cent of the dosimeters tested gave readings within plus or minus 25 per cent of the NBS reading. In one case as many as one half of the dosimeters at a given exposure gave values 67 per cent in error of the NBS value. Table 2.2 gives the results of exposure for Shot 3.

2.7.2 Discussion

The dosimeters tested did not show a pink tinge as did the DT-65/PD and consequently were easier to read. The poor reproducibility was, therefore, attributed to response of the emulsion and not error. It was known before the test that the amount of development work done on the DT-64/PD was somewhat less than that done on the DT-65/PD, however the test was performed to determine the present status.

2.7.3 Conclusions

The results of the test of the DT-64/PD photographic dosimeter indicate that it has not been developed to the point where it can be considered satisfactory for interim use.

2.7.4 Recommendations

In view of the present military requirements and the status of the development of the DT-64/PD, it is recommended that careful

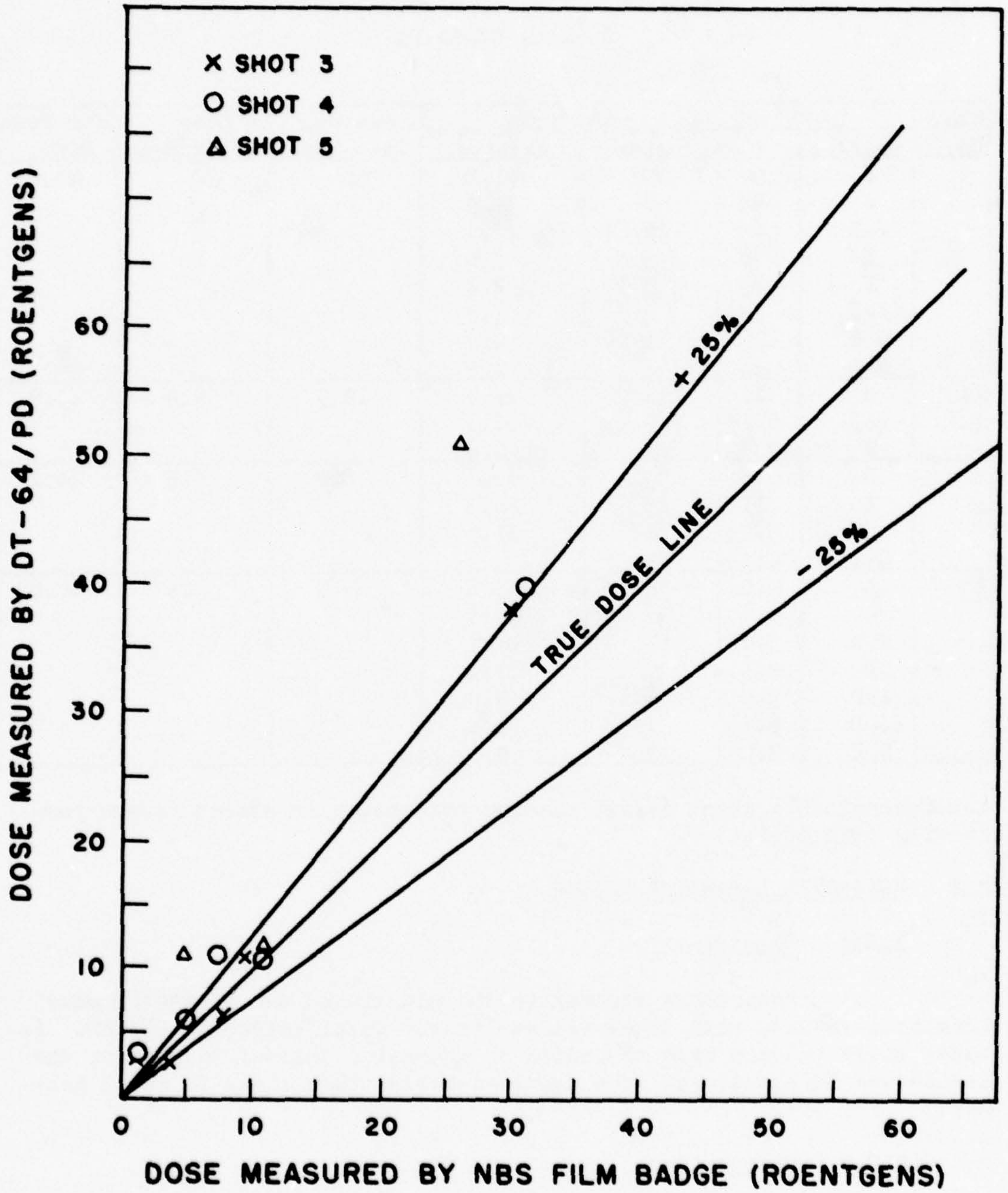

Fig. 2.3 Results, DT-64/PD

TABLE 2.2

Results DT-64/PD

Sta. No.	Dose Step	Dose r	Readings Number	Readings Per Cent	Average Dose Read	Dose NBS Badge	Per Cent Diff.
9	K	50	60	43.2	38	30	26.6
	J	40	48	34.5			
	J-K	45	19	13.7			
	L	60	5	3.6			
	H	23	3	2.2			
	I-J	35	2	1.4			
	G-H	19	1	0.7			
	K-L	55	1	0.7			
11	E	11	111	91.7	10.9	9.4	15.9
	D-E	9.25	9	7.5			
	D	7.5	1	0.8			
12	D	7.5	93	67.4	8.2	6.6	24.2
	E	11	28	20.3			
	D-E	9.25	16	11.6			
	C-D	6.35	1				
13	B	4.0	52	43.8	4.0	2.5	60.0
	C	6.0	37	31.1			
	B-C	5.0	13	10.9			
	D	7.5	9	7.6			
	A-B	3.9	6	5.0			
	C-D	6.35	1	0.8			
	D-E	9.25	1	0.8			

consideration be given before placing more money or effort toward perfecting this dosimeter.

2.8 PH-650/PD DOSIMETER HOLDER

2.8.1 Results

Dosimeters exposed in the plastic holder PH-650/PD gave identical results with those exposed in the metal holder PH-656/PD. In cases where holders were subjected to excessive thermal radiation, the dosimeters in plastic holders survived better than those in metal holders.

2.8.2 Discussion

Dosimeters DT-65/PD were exposed to the same doses and under the same conditions in both the metal self-developing holder PH-656/PD, tested at BUSTER-JANGLE, and the plastic, non self-developing holder PH-650/PD. In no case could a difference be detected between

those dosimeters exposed in the PH-656/PD and the PH-650/PD. In cases where the dosimeters were exposed to thermal radiation sufficient to cause heat damage to the dosimeter element in the metal holder, those dosimeters in plastic holders were not similarly affected. Although the plastic holders were fused and burned on the outside, the dosimeter was not affected. This resulted from the poor heat conductivity of the plastic and the short duration of the thermal radiation. The heat required to damage the plastic holder beyond use would, in every case, have caused serious casualties to personnel.

No tests were made on the PH-650/PD with reference to ruggedness, serviceability, and ability to withstand normal use and abuse. These tests are presently being conducted by Army Field Forces. However, the models used at the Nevada Proving Grounds were reinforced as a result of previous tests by Army Field Forces to prevent the breakage of pods in normal use.

2.8.3 Conclusions

It is concluded that the Dosimeter Holder PH-650/PD is satisfactory for use with the photographic dosimeter DT-65/PD with respect to its response to the energy spectrum of an atomic detonation.

2.8.4 Recommendations

It is recommended that the production and procurement of the PH-650/PD be given priority consistent with the application of the photographic dosimeter DT-65/PD.

2.9 TAPLIN DOSIMETER

2.9.1 Results

Model E of the Taplin Dosimeter was tested at Shots 4 and 5, and models E and F were tested at Shots 7 and 8. Results are given in Table 2.3.

2.9.2 Discussion

The model E dosimeters were, when exposed to Shots 4 and 5, the latest models available for test. However, when it was shown that the dose indicated by these dosimeters for Shots 4 and 5 were considerably lower than that recorded by the standard, certain changes were made in the dosimeter by the manufacturer. The corrected dosimeter was made available to the project as model F. These dosimeters were exposed to Shots 7 and 8.

It will be noted from the results that in many cases

these dosimeters were neither accurate nor consistent. Dosimeters exposed to the same dose varied by as many as three steps. Model F was somewhat more consistent than model E but was still lacking in accuracy.

The packaging of the dosimeter is fairly rugged, but bulky.

2.9.3 Conclusions

The Taplin Dosimeter is not, in its present development status, satisfactory for military use.

2.9.4 Recommendations

It is recommended that the development of the Taplin Dosimeter be continued, consistent with the military dosimeter program as a whole.

2.10 DT-51/PD COLOR CHANGING CRYSTAL DOSIMETER

2.10.1 Results

Approximately 40 DT-51/PD dosimeters were tested at Shot 3. The results are given in Table 2.4. Approximately 69 per cent of the dosimeters read within 25 per cent of the NBS film badge reading.

After Shot 3 these crystals became wet and, being hygroscopic, failed to perform satisfactorily subsequent to that time.

2.10.2 Discussion

A disadvantage of the DT-51/PD is that it is subject to moisture. Once fogged by moisture, they failed to give satisfactory results.

2.10.3 Conclusions

The results indicate that the DT-51/PD in its present form is not satisfactory for military use.

2.10.4 Recommendations

It is recommended that proposed work on the DT-51/PD be reconsidered, consistent with the dosimeter program as a whole.

[redacted]

TABLE 2.3

Results, Taplin Dosimeter

Sta. No.	Taplin D. Reading	Number of Readings		N.B.S. Reading
		Observer #1	Observer #2	
1	>600	21	21	>2000
2	>600 600	16 3	19 -	2000
3	>600 600	17 3	20 -	1475
4	>600 600	1 20	21 -	980
5	>600 <600 >400 400 <400	- 14 - 1 5	1 1 16 1 1	600
6	>200 200 <200 50	1 3 8 7	- 8 11 -	290
7	50 < 50	3 16	6 13	129
8	< 50	15	15	94
9	< 50	15	15	57
10	< 50	15	15	26

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TABLE 2.4

Results DT-51/PD Crystal Dosimeter

Sta. No.	Crystal No.	Dosage	N.B.S. Dosage	Per Cent Diff.
3	1	441	432	+ 2.1
	2	146		-66.3
	3	441		+ 2.1
	4	404		-6.5
	5	219		-49.4
	6	452		+ 4.6
	7	-		-
	8	456		+ 5.6
	9	-		-
6	10	133	182	-26.9
	11	163		-10.2
	12	195		+ 7.2
	13	132		-27.4
	14	92		-49.4
	15	82		-54.8
	16	175		-3.8
	17	179		-1.6
	18	94		-48.3
	19	189		+ 3.8
7	20	68	134	-49.0
	21	136		+ 1.5
	22	129		-3.7
	23	137		+ 2.2
	24	134		0.0
	25	94		-29.7
	26	140		+ 4.5
	27	116		-13.4
	28	110		-17.9
	29	141		+ 5.2
10	30	23	21	+ 9.5
	31	20		-4.8
	32	20		-4.8
	33	21		0.0
	34	24		+ 14.2
	35	18		-14.2
	36	18		-14.2
	37	18		-14.2
	38	20		-4.8
	39	18		-14.2

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2.11 DT-67/PD CONDUCTION CRYSTAL DOSIMETER

2.11.1 Results

Approximately 30 DT-67/PD Dosimeters were exposed to each of five shots. Table 2.5 shows the typical results obtained. The dose indicated by the dosimeters exposed to the bomb spectrum gave results up to 70 per cent higher than the standard NBS film badges. The results were not consistent, however.

2.11.2 Discussion

The dosimeters tested were calibrated before exposure with a Cobalt 60 source. After exposure, the calibration was checked, again with Cobalt 60, and was in agreement with the first calibration. The high reading obtained by exposing the dosimeters to the bomb spectrum would, then, indicate that the crystals are not energy independent.

2.11.3 Conclusion

The Dosimeter DT-67/PD is not, in its present development status, satisfactory for military use.

2.11.4 Recommendations

It is recommended that the proposed development work be reconsidered consistent with the dosimeter program as a whole.

2.12 PATTERSON-MOOS "ATOMETER"

2.12.1 Results

The "Atometer" was exposed to Shots 3 and 5. The results are given in Table 2.6. The readings are neither consistent nor accurate. The difference in color between steps is not sufficient to permit accurate reading of the dose registered. The packaging was not sufficiently rugged for normal handling.

2.12.2 Discussion

The greatest difficulty encountered with the "Atometer" was in determining the color matching. In many cases two observers read the dose indicated by a difference of two steps. It was found that color blind people could not read the dosimeters at all.

Much difficulty was experienced with the packaging. In a number of cases the fluid had leaked out of its container.

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TABLE 2.5

Results, DT-67/PD Conduction Crystal Dosimeter

Sta. No.	Crystal No.	Crystal Dosage	N.B.S. Reading	Per Cent Diff.
8	53	250	195	+28.2
	174	>250		--
	46	210		+ 7.7
	49	180		-7.7
	64	>250		--
	172	---		--
9	170	105	65	+61.5
	62	90		+38.5
	38	111		+71.0
	33	111		+71.0
	51	90		+38.5
	63	---		--
	23	105		+61.5

2.12.3 Conclusions

The Patterson-Moos "Atometer" is entirely unsatisfactory for military use.

2.12.4 Recommendations

It is recommended that the "Atometer" not be considered for military use.

2.13 PATTERSON-MOOS PHOSPHOR DOSIMETER

2.13.1 Results

The Patterson-Moos Phosphor Dosimeter was tested at Shots 6, 7, and 8. The results were so inconsistent that no correlation could be made between the dose readings and the values given by the NBS film badges. Table 2.7 shows the data for Shot 6.

2.13.2 Discussion

The results show that the Patterson-Moos Phosphor Dosimeter is neither consistent nor accurate. It is realized, however, that the element tested is in an early development stage. It would

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TABLE 2.6

Results, Patterson-Moos Atometer

Sta. No.	Atometer Reading	Number of Readings			N.B.S. Reading
		Observer #1	Observer #2	Observer #3	
1	600 400	9 1	6 4	5 5	832
2	600 400	4 6	- 10	1 9	560
3	400	5	5	5	460
4	400 150	7 2	2 7	6 3	374
5	400 150 <150 50	1 6 1 1	- 6 1 3	1 9 - -	232
6	150 50	7 -	5 2	6 1	182
7	150 50 0	8 1 0	- 8 2	1 9 -	134
8	150 50 0	8 1 -	- - 10	- 4 6	73
9	150 <150 50 0	2 4 3 -	- - 2 7	- - - 8	30
10	150 50 0	5 5 -	- 3 7	- - 10	21
11	150 50 0	7 3 -	- 2 7	- 1 10	9.4
12	<150 50 0	2 8 -	- - 10	- - 10	6.6

TABLE 2.7

Results, Patterson-Moos Phosphor Dosimeter

Sta. No.	Atometer Reading	Number of Readings		N.B.S Reading
		Observer #1	Observer #2	
1	600	2	2	Over 2000
3	600	5	5	1475
4	600 400	4 1	3 2	980
5	600 400	- 3	1 2	600
6	150 50	5 -	2 3	290
7	50	5	5	129
8	50	4	4	95
9	50 150	5 -	4 1	57

not have been tested if the facilities had not been provided for testing other devices.

2.13.3 <u>Conclusions</u>

The Patterson-Moos Phosphor Dosimeter in its present form is not adequate for military use.

2.13.4 <u>Recommendations</u>

It is recommended that the military participation in the development of the Patterson-Moos Phosphor Dosimeter be reconsidered pending clarification of the dosimeter program as a whole.

2.14 DOSIMETER CHARGER PP-354C/PD

2.14.1 Results

Conclusive results cannot be obtained from the limited testing performed on this device. However, for the conditions that existed with respect to humidity, temperature, etc., and with the limited use, no failures resulted. The size and operational simplicity are excellent.

2.14.2 Discussion

No program for testing fiber type dosimeters was conducted as a part of Project 6.1 and no opportunity for extensive and continuous use were available. The chargers were used to service those fiber dosimeters which were used as a part of other project functions.

2.14.3 Conclusions

The Dosimeter Charger PP-354C/PD is superior in size and convenience to any charger presently available. The unit was used sufficiently to determine its dependability or maintenance problems. However, there was no evidence to indicate that it is deficient in those respects.

2.14.4 Recommendations

It is recommended that full testing of the Charger PP-354C/PD be conducted to determine its adequacy for military use.

2.15 DOSIMETERS - GENERAL

2.15.1 Conclusions

None of the dosimeters tested can be considered entirely satisfactory for military use. The DT-65/PD with its metal and plastic holders can be considered satisfactory for interim military use and is the most promising of any dosimeter tested at this operation. The failure of this dosimeter above approximately 350 r, not evident in previous models because of their lower ranges, indicates that further analysis is required.

It may be stated further that there is no dosimeter available which can be considered entirely adequate for military use. The DT-60/PD phosphate glass dosimeter gave excellent results during its preliminary testing at BUSTER and shows promise. However, it is still under development, and was not available for further testing at this operation.

2.15.2 **Recommendations**

It is recommended that all dosimeters presently under development for or consideration of the military services be analyzed competitively with respect to cost, status, feasibility, etc., in order that a more coordinated dosimeter program will result. It is suggested that the requirements for a dose measuring device be made more firm to guide those agencies engaged in these activities. For instance, a decision should be made as to whether or not a step-type dosimeter is satisfactory, and if so, what the steps should be. It is felt that the Polaroid dosimeter problem could be simplified considerably by going to four or six steps, for example. If twelve steps are required, other dosimeters may automatically become impractical. All of the available facts should be considered to reduce cost and eliminate duplicate effort.

CHAPTER 3

RAPID AERIAL SURVEY

3.1 ABSTRACT

On Shot 7 of Operation SNAPPER a rapid aerial survey of the contaminated area was conducted using an LC-126 Liaison type aircraft and existing portable military radiac equipment. The results obtained indicate that using a survey meter, such as an AN/PDR-T1B or AN/PDR-18, and a stop watch it is possible to determine, well within an order of magnitude, the contamination on the ground at a given spot. This method shows promise for making an initial post-shot survey for a field commander, a radiological safety organization, or civil defense.

3.2 OBJECTIVE

The objective of the rapid aerial survey was to further develop the technique employed during Operation JANGLE to determine centers and extent of ground contamination together with orders of magnitude of these contaminated areas. It was desired to further simplify the equipment required by performing the survey using only an AN/PDR-T1B and a stop watch. The purpose of developing such a technique is to point out a method for a survey by which a field commander can arrive at a rapid determination of radiological hazards that exist, should the need arise.

3.3 BACKGROUND AND THEORETICAL DATA

This technique for conducting a rapid aerial survey was employed during Operation JANGLE. The agreement attained with readings taken on the ground by other independent means was sufficiently good to warrant further thought and testing. See report, Project 6.1, Operation JANGLE.

3.4 INSTRUMENTATION

The following equipment was used in conducting the survey:

1. A standard Radiac Training Set AN/PDR-T1B
2. A Radiac Training Set AN/PDR-T1B modified to record the meter reading by feeding the output through a d.c. amplifier to a recorder.
3. A Radiac Set AN/PDR-18 modified as the above AN/PDR-T1B.

3.5 OPERATION

The radiological survey was conducted using an LC-126 aircraft, an AN/PDR-T1B, and a stop watch.

In order to determine the contamination at a given point on the ground, it is necessary to fly over the spot at three or more altitudes and use the values obtained to plot a curve which, when extrapolated downward, gives a value for the dose-rate at the desired point.

The actual pattern used in a tactical situation depends on the information desired and the terrain. During this operation it was necessary to limit the survey in order to remain within the tolerance limits set by the Radiological Safety Organization.

In order to tie down the dose-rate measurements to specific points near the ground, it was necessary to fly the pattern employing constant speed, altitude, and direction for each leg. During the operation using only a survey meter and a stop watch, it was necessary to select a point on the ground as a zero position. Taking readings at specific time intervals, 5 seconds in this case, tied all readings to specific points on the ground. (See Fig. 3.1).

To provide a check for the results obtained two automatic recording equipments were used. An AN/PDR-T1B and an AN/PDR-18 were modified slightly to allow the signal at the meter to be recorded. In this case a zero time point and the time base of the recorder chart were used to tie down the recorded values to specific points on the ground.

The speed of the plane permits survey of high dose-rate areas without subjecting the operators to large doses. Although high dose-rates were encountered the doses obtained were approximately 2 r.

3.6 RESULTS

Figure 3.2 shows a graphical comparison of the results obtained using the recording equipment and that obtained using a radiacmeter and a stop watch. The peak of both curves was obtained from a reading on the AN/PDR-18 because of its range. The value of the contamination at ground level can be obtained from the peak readings and the readings near the peak. However the values on both sides of the peak are not sufficiently accurate for such an extrapolation. Because of the short time involved in flying over the area, range switching is not practical. This means it is necessary to choose that meter scale in which the monitor is interested. The results shown were obtained with the T1B on the 50 r/hr scale. One possible solution, which should be tried, is the use of an instrument with a logarithmic scale.

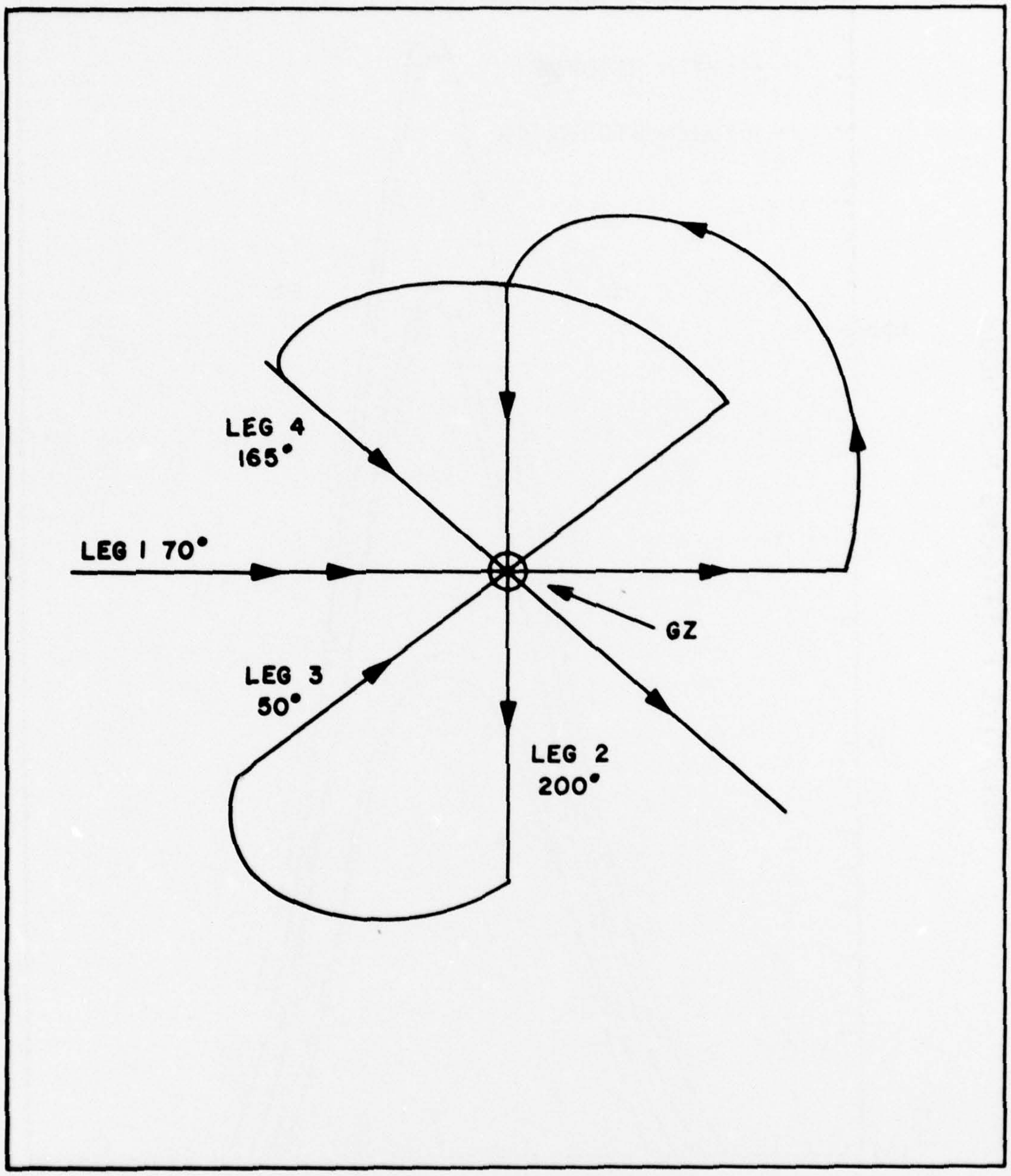

Fig. 3.1 Flight Pattern, Rapid Aerial Survey

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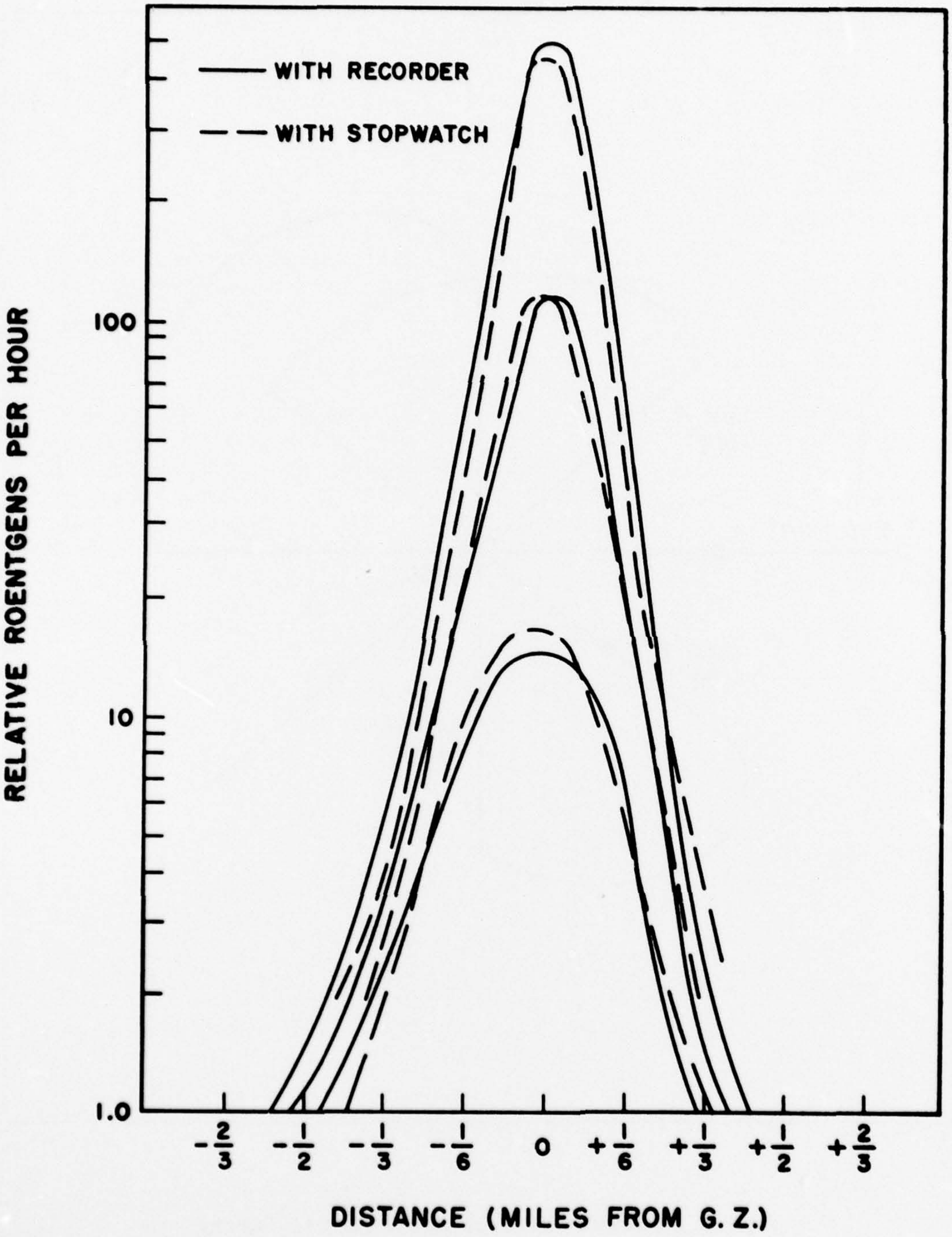

Fig. 3.2 Results, Rapid Aerial Survey

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3.7 DISCUSSION

The accuracy of the results obtained by the method employed is sacrificed to a certain extent for speed and simplicity. However, the accuracy of such an operation depends to a large extent on the operator and the pilot. Practice is necessary before reliable results can be expected.

It should be pointed out that this method has a limited resolution, because of the time-constant of the radiacmeter. It should not be considered adequate for determining with any accuracy the magnitude of the contamination of small isolated spots.

3.8 CONCLUSIONS

A quick and fairly accurate survey of a contaminated area can be made, using a small aircraft and simple radiac equipment, both available to the field commander. The speed with which such a survey can be made more than compensates for the lack of accuracy. This technique could be employed by a ground commander in a tactical situation and also offers certain advantages to Radiological Safety and Civil Defense organizations for initial post-shot surveys.

3.9 RECOMMENDATIONS

It is recommended that this area survey technique be considered for use as a standard tactical doctrine.

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APPENDIX A

DIRECTIONALITY OF INSTRUMENTS

It has long been recognized that the necessary inclusion of massive electronic components in the radiac equipment, unsymmetrically arranged about the detector, makes the radiac equipment's sensitivity to radiation as a function of the alignment of the radiac in the field, as well as of the "angular dependence" of the field itself. Further, the unavoidable partial shielding of the detector insures that the energy dependent response of the equipment to radiation is also a function of angular position. The question arises whether current military radiac equipments are seriously deficient in their task of measuring scalar dose rate in typical weapons contamination fields on account of these effects.

At Shot 3, a crude experiment was performed to permit an estimate of the importance of these factors. A T1B radiac chassis was equipped with an external 1 inch lead shielded ionization chamber with a 1 inch round collimation port and a plug for the latter. Sixteen azimuthal readings of the field were obtained at a point 80 yards from ground zero with the directional instrument, an AN/PDR-18, and an AN/PDR-T1B.

The directional intensities were obtained by zeroing the instrument with the collimation port plugged, unplugging the port, and reading.

The azimuthal directionalities of the AN/PDR-T1B and the AN/PDR-18 were measured in the field. The observed field azimuthal directionality is shown in Figure A.1.

The directional variation of the instrument sensitivity is shown in Figures A.2 and A.3.

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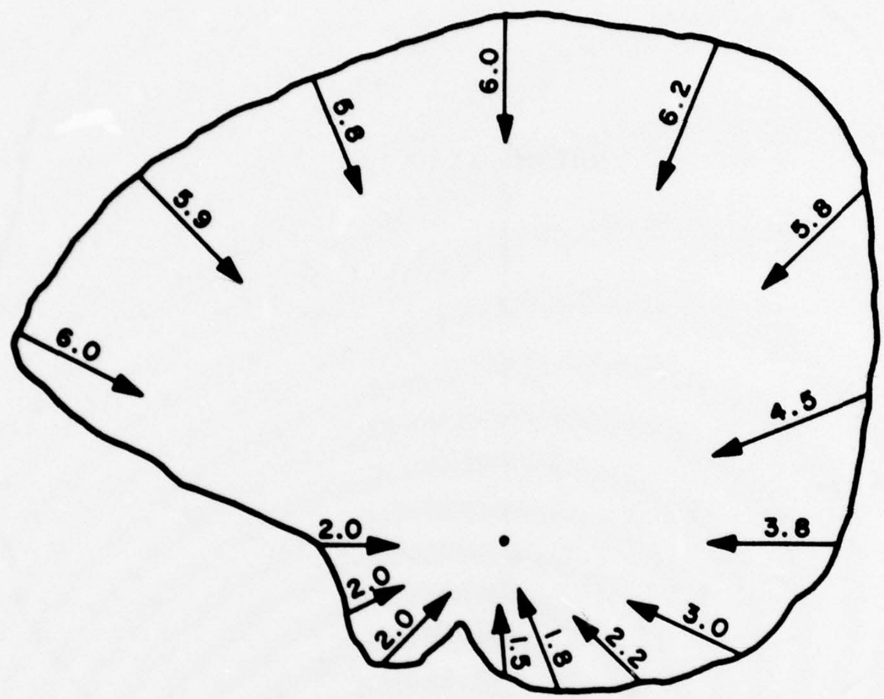

Fig. A.1 Field Azimuthal Directionality, Determined With The Directional Detector, Indicated Fluxes Are Relative Meter Readings

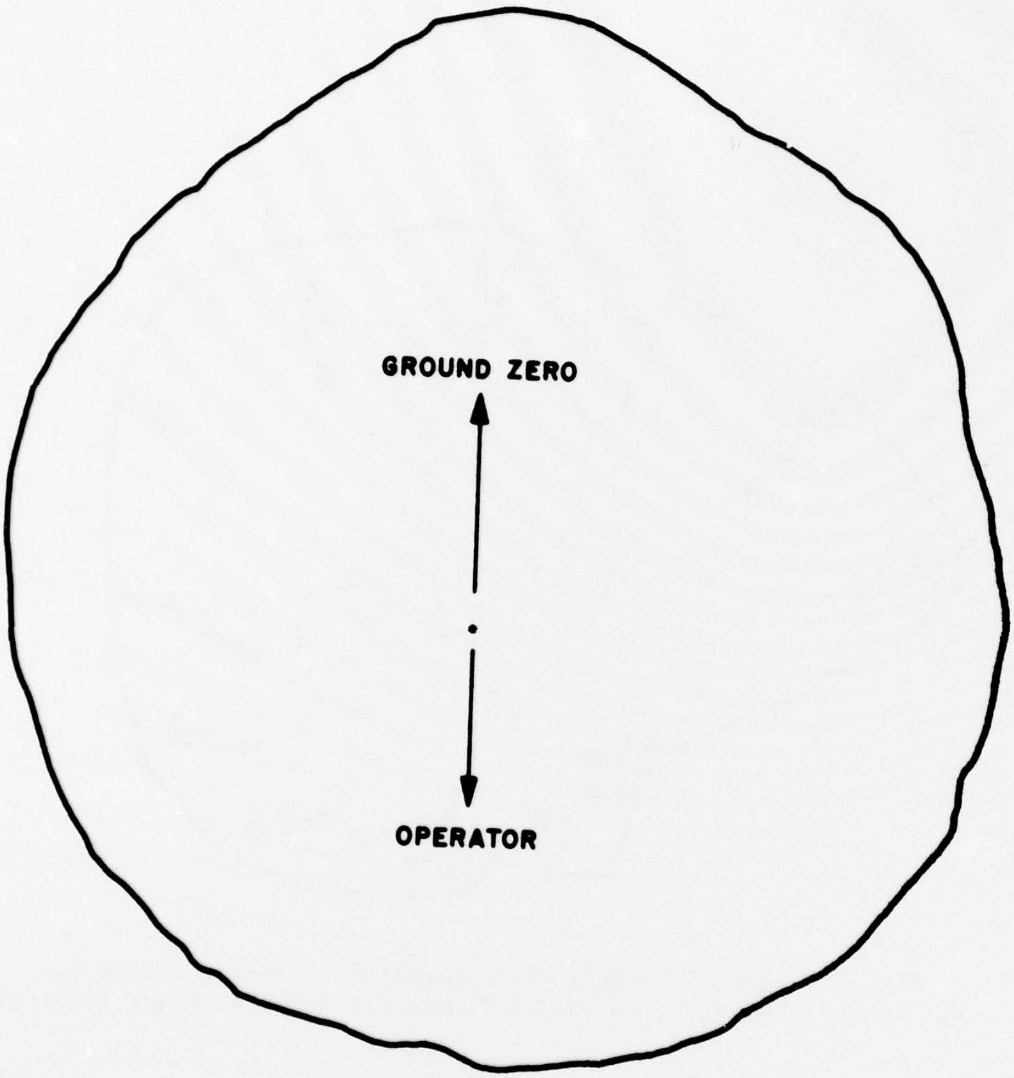

Fig. A.2 Response of The AN/PDR-18 To Radiation Field of Fig. A.1

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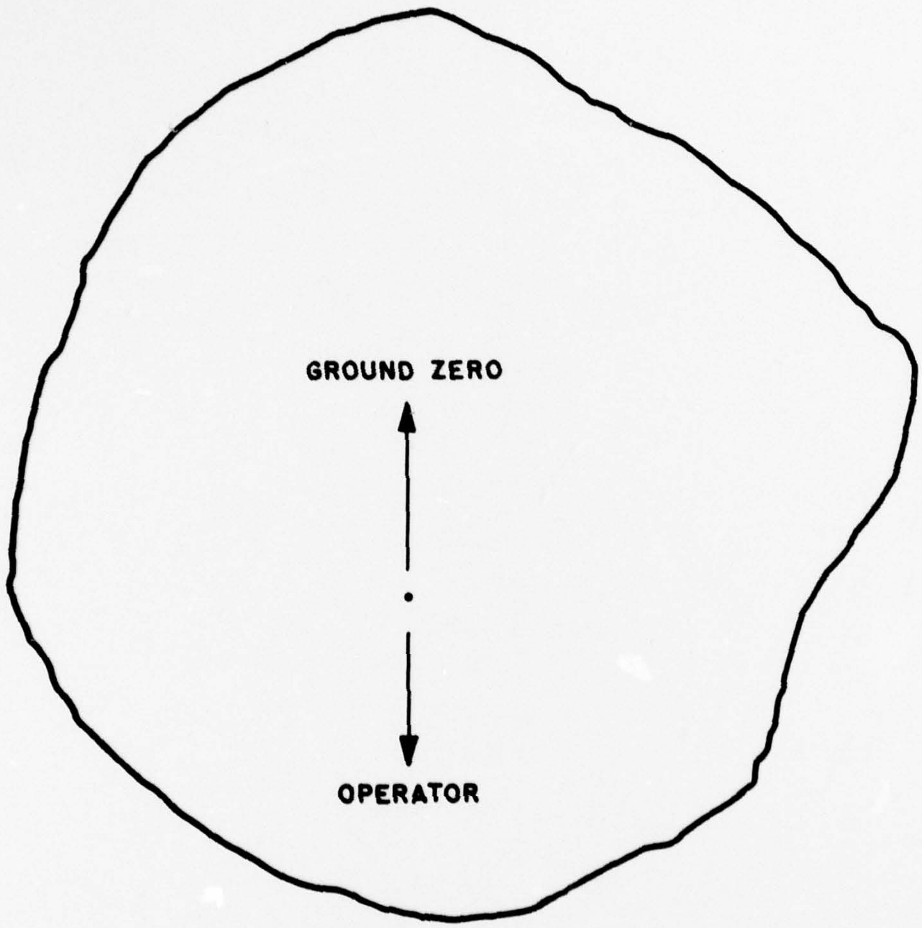

Fig. A.3 Response of AN/PDR-T1B To Radiation Field of Fig. A.1

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